



Small - Display Cartography

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Small - Display Cartography

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Abstract: This report comprises the work carried out in the work-package of small display cartography. The work-package has aimed at creating a general framework for the small-display cartography. A solid framework facilitates an increased use of spatial data in mobile devices - thus enabling, together with the rapidly evolving positioning techniques, a new category of position-dependent, map-based services to be introduced. The report consists of the following parts: Part I: Categorization of handheld devices, Part II: Cartographic design for small-display devices, Part III: Study on the GiMoDig Client – Portal Service Communication and finally, Part IV: Concluding remarks and topics for further research on small-display cartography. Part II includes a separate Appendix D consisting of a cartographic design specification. Part III includes a separate Appendix C consisting of a schema specification, a separate Appendix E consisting of confidential material and Appendix F with examples.

The work has resulted in a small device categorisation, a cartographic design specification for a small-display device for a specified navigation task as well as a comparison between OpenLS and an in house developed protocol for communicating between client and a portal service.

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Executive summary

Introduction

This report comprises the work carried out in the work-package of small display cartography in the “Geospatial info-mobility service by real-time data-integration and generalisation” (GiMoDig) - project. The work-package has aimed at creating a general framework for the small-display cartography. A solid framework facilitates an increased use of spatial data in mobile devices - thus enabling, together with the rapidly evolving positioning techniques, a new category of position-dependent, map-based services to be introduced. The results of this work also provide input for the considerations related to the work carried out in the work-package of real-time generalisation.

The report consists of the following parts:

- Part I: Categorization of handheld devices
- Part II: Study on the cartographic design for small-display devices

This part includes a separate Appendix D consisting of a cartographic design specification.

- Part III: Study on the GiMoDig Client – Portal Service Communication

This part includes a separate Appendix C consisting of a schema specification and a confidential discussion on the OpenLS specification in Appendix E and Appendix F that contains examples of protocol communication.

- Part IV: Concluding remarks and topics for further research on small-display cartography.

Categorization of handheld devices

The GiMoDig project was supposed to make a study of the handheld devices available on the market in order to make a categorization of the devices. However, during the study it has showed up that the market is changing rapidly and the technology is moving fast from the 2nd generation GSM mobile net towards the 3rd generation GPRS and UMTS.

Instead of making a complete study of the devices available, the demands from the GiMoDig project has been compared against selected devices to see whether there exist any discrepancies between the demands from the project and the available functionality. Based on that comparison, it can be concluded, that it will be possible, even with the present technology, to make spatial information from the server-prototype of the project available to handheld devices.

Cartographic design for small-display devices

A basic precondition is the thought of a special purpose solution to a specific task when developing a cartography to a small-display device. A use case: “A tourist in a unfamiliar city”, has been selected in order to frame the necessary investigations and development. The result in form of a cartographic design to meet the objective has been proposed. The solution is based on: easy readable font, easy recognisable signs and symbols, mutual exclusive colours on each level of information and a comprehensible usage of area colours with few geometric details of objects.

Study on the GiMoDig client – portal service communication

This part of the report is an investigation of the protocol to be used in the two-way communication between a GiMoDig client application and the GiMoDig portal service – two upper layers in the proposed GiMoDig system architecture. This protocol concentrates on parameters needed in formulating a map query to be transmitted from a mobile device to the portal service.

Conclusions

This report contains among other things 3 aspects concerning cartography on a small-display handheld device: a survey of small handheld devices and a categorisation of those, a cartographic design specification for a certain mobile navigational application and a proposal for an interface protocol between the client (handheld device) and the portal layer which is supposed to support a variety of end user clients.

The core work is designing a cartography for a tourist navigational task. This relative narrow solution can probably not be a basis for a more general solution. Further work is necessary to test the visual limits in terms of light reflections and night conditions. An extension study to cover a more comprehensive set of point of interest symbols would be valuable besides the need to cover design of cartographic object types that are neglected in this context.

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The report has been peer reviewed by professor Georg Gartner at the Vienna University of Technology. We are very content with the review and thank Professor Gartner for his comments and suggestions.

Finally the WP3 group wish to thank Tapani Sarjakoski, the Finnish Geodetic Institute for his calm and inspiring work as a coordinator on the GiMoDig-project.

Preface

Small-display cartography

1 Scope for the report

The “Geospatial info-mobility service by real-time data-integration and generalisation” (GiMoDig) – project’s work on the use of online, integrated and generalised geo-spatial data on small handheld devices is divided into work packages. This report comprises the work carried out in the work-package on small display cartography (WP3) and the delivery on this work is planned to be finalised around the end of the first third of the project’s time table (GiMoDig, 2003). The work-package has aimed at creating a general framework for small-display cartography. A solid framework facilitates an increased use of spatial data in mobile terminals - thus enabling, together with the rapidly evolving positioning techniques, a new category of position-dependent, map-based services to be introduced. The results of this work also provide input for the considerations related to the work carried out in the work-package of real-time generalisation.

To understand the demands for small-display cartography, some general user requirements must be considered. The end user depending on a mobile terminal should understand the map graphics well enough to recognise the surroundings on the map in the case of a service depicting the end user’s own position. Another case is searching and finding interesting places and getting instructions about how to reach them from the end user’s current location. Furthermore, the end user must communicate with the server in an easy way in order to get the optimum graphic result. This requires an intuitive communication interface with the positioning service at hand.

2 Organization of the report

The report consists of the following parts:

- Part I: Categorization of handheld devices
- Part II: Cartographic design for small-display devices

This part includes a separate Appendix D consisting of a cartographic design specification.

- Part III: Study on the GiMoDig client – portal service communication

This part includes a separate Appendix C consisting of a schema specification and a confidential part in Appendix E.

- Part IV: Concluding remarks and main results on small-display cartography.

Part I

Categorization of handheld devices

1 Background of handheld devices

The scope of the GiMoDig project is to bring spatial information in the shape of a map to the users' mobile handheld devices in real time mode. This, by itself, makes some demands on the devices to be used for the project. The scope of Part I is to present an overview of selected handheld devices present available on the market appropriate to be used in the GiMoDig project and to categorise the devices.

During the research it became clear that the mobile market are in the middle of a rapid change from 2nd generation GSM through 2 ½ generation GSM/GPRS towards UMTS. These changes, that are not yet fulfilled, are going to have a tremendous influence on the capabilities of the handheld devices. How big it will be is impossible to say, only indications are available, but it seems clear, that the demands from the GiMoDig project will not give any problems for the next generations of mobile phones or similar handheld devices. Because of this very unstable situation, we have not found it expedient to do a full scanning of the market for devices present available. We believe that such a detailed market scanning will be of no use for the project, if carried through at this stage of the project. This should be seen in the light of the timeframe of the whole project that should be ended by the end of 2004; nearly 2 years after WP3 has been finished and by that time UMTS will have another status. This part should therefore be considered an up-to-the-minute account.

To be able to compare the capacity of the devices with the demands from the GiMoDig project we have made some assumptions based on Annex 1 – “Description of Work” and papers already available from “WP4: System Architecture”, and of course premises from the work packages “WP3: Small Display Cartography” it self.

In short, the requirements from the GiMoDig project raise some demands to the display, the communication and the ability to add further software functionality to the device. These demands will considerably narrow the number of possible devices to be used.

2 Assumptions

This section lists assumptions made, to be able to make the study focusing on the proper devices, and later on in Part I to be able to make recommendations.

1. In WP3 it has been decided that the small display cartography should be developed for colour displays with a size of around 180 x 180 pixels or more.
2. It has been decided that the communication should be based on packet-based communication because that enables the device to be continuously online. The user can thereby be warned immediately if he is moving out of the proposed route and the

communication speed can be significantly higher compared with the techniques used for non-packet based communication. At present GPRS is the only broadly available technique for packet-based communicating in Europe.

3. It is assumed that the device “knows where it is”, either calculated on the basis of the cell phone transmitters or by built-in GPS capabilities.
4. The use of Java ME (Micro Edition) on the client, as premises by WP4, makes demands to either built-in Java ME or the possibility to upgrade the device with Java capabilities. Anyhow, the device should have enough memory to run the applet and hold the map.

3 Study

In an attempt to clarify the different kind of handheld devices and their abilities, the Internet has been used, to make a study on what is available now and in the very near future. The study has focused on the devices present available or announced on the European market. The sources for the study have been the manufactures’ homepages and various on-line magazines like ZDNet UK (ZDNet UK News, 2002).

In general, it is very difficult to get technical details like the number of pixels in the display or the specific number of grey tones or colours for mobile phones. If an indication of the resolution is given, it is normally given in number of lines in the display. These specifications are much easier to get for PDAs and telephones with built in PDA capabilities.

After a brief market scanning has been carried out it seems clear that the demands from the GiMoDig project are in no way unrealistic, especially not when the time horizon for the project is taken into consideration. However, presently there exist only very few multi functional handheld devices that have the capability to act both as a communication device (telephone) and as a hand held computer. However, there have been announced several new multifunction devices to come into the market during this year. Appendix A gives a list of selected handheld devices.

As both WAP and I-mode are running on top of GPRS and I-mode presently is not widely available on the European market there has not been any distinguishing between the two.

The present situation compared with the assumptions in Section 2 is outlined in the following Sections 3.1-3.4.

3.1 Display

No mainstream phones presently have a colour display or a display size that fulfils the assumptions made. However, both Nokia and Sony Ericsson already have or have announced high-end mobile phones supplied with colour display. During the period of the GiMoDig project, colour displays on mobile phones must be expected to be available on mainstream phones as well.

3.2 GPRS

The General Packet Radio Service (GPRS) is a new non-voice value added service that allows information to be sent and received across a mobile telephone network. It supplements today’s Circuit Switched Data and Short Message Service, and gives the

users the possibility to be constant connected to the network. Presently there are about 100 devices available supporting GPRS (GSM World, 2003). For the time being, there are some limitations in the possibilities to use GPRS across frontiers because not all operators have roaming agreements. However, one of the major players, Vodafone, who is covering 12 European countries, has announced that it will try to enter agreements with partners all over Europe. In the Nordic countries Telia customers can use GPRS in Denmark, Sweden and Finland. In addition the GSM Association, that is the world's leading wireless industry representative body, consisting of more than 600 second and third generation wireless network operators and key manufacturers and suppliers to the wireless industry, recently held a plenary meeting in Istanbul (in October 2002). GPRS-roaming was on top of the agenda (GSM World, 2002). Because of these initiatives the problems are expected to be solved.

3.3 UMTS

UMTS is the third generation of mobile telephony and allows, like GPRS packet based communication. The transmission speed will be significantly higher (from 384 Kbs for fully mobile users to 2 Mbs for stationary users) than what was known previously and was the reason for implementing the technology. Europe's UMTS operators were expected to lead the way to 3G services. Instead, they have been plagued by equipment delays, debt (much of it from spectrum auctions), and a sour investment climate. The UMTS operators face serious challenges. Many can't afford to build nationwide networks in the 2.1 GHz band. Dual mode handsets (W-CDMA/GSM) will take time to perfect (Datacomm Research Company, 2002). Although the establishment of the UMTS-network has begun in several European countries the pace is somehow hampered as it appears from the previous. However, when the new infrastructure is established it will allow ubiquitous, always-on, high-speed access to voice, data and multimedia services (source: IBM, 2001), and lots of new services is expected. The devices intended to be used for these services are expected to have all the multimedia capabilities necessary to support the GiMoDig work.

3.4 Future wireless development

Even before UMTS, the third generation mobile network is rolled out, the fourth generation is on its way. The fourth generation wireless may be rolled out within the end of this year (2003). The fourth generation network, that mainly is considered to be IP-based cellular systems are available from several wireless vendors, while a number of different air interfaces are now being readied for beta deployments by leading wireless operators since the fourth generation technologies offer a low cost and/or higher performance alternative to traditional third generation systems. The fourth generation digital IP-based high-speed cellular systems are anticipated to account for 14 % of total mobile wireless data revenues in 2007. Mobile operators are already using technologies from wireless LAN to complement existing services. Coupled with 2½ generation technologies such as GPRS these technologies can provide wide coverage at roughly analog modem speeds and fast data rates in areas with heavy user traffic (Sundgot, 2002).

3.5 Awareness of location

As mentioned earlier, we assume that the mobile device knows its location. Presently, the only way to get a position that fulfils the assumptions made in WP3, is by GPS. The GPS equipped mobile phone is already on its way to the market. For instance, Sony Ericsson has unveiled the T206 featuring GPS for the North American market and Benefon has released the GPS equipped Benefon Esc! that besides the GPS capabilities is able to store a map locally on the phone. In contrast to the intention in the GiMoDig project the

maps are predefined and have to be downloaded in their entirety for the area of interest before they can be used. In that way the functionality can be compared with the route planning software for laptops and PCs.

In the project group it is expected that the question of position will be solved either by built in GPS receivers or by the phone's ability to calculate a position based on the transmitters actually used. However, locations calculated as cell positions seem not yet to have an appropriate accuracy for the intended functionality in the GiMoDig project. The required accuracy to give the right indications for the pedestrians is estimated to be better than 15 m. In urban areas the accuracy in cellular positioning is expected to be within 50 - 200 m while the accuracy in rural areas can be expected to be as bad as 1000 - 2000 m. Both figures are depending of the technology used. The limitations in the GPS positioning are caused by the fact that the GPS receiver has to have unhindered sight to the necessary satellites to be able to supply a proper position. Therefore the accuracy of the position is affected negatively if the user is moving along near tall buildings etc. or maybe moving inside buildings like shopping centres.

There are several ways to improve the accuracy. E-OTD (Enhanced Observed Time Difference) improves accuracy, but is expensive, operates only on GSM/GPRS and requires major changes to the infrastructure that makes its deployment throughout multiple networks with independent operators cumbersome and unlikely. OTDOA (Observed Timed Difference of Arrival) is similar to E-OTD, but may provide lower yield and operates only on UMTS networks. A-GPS (Assisted GPS) offers very good overall performance, easily supports roaming and network expansion, provides compatibility across 2G, 2½G and 3G networks and has a much lower cost than E-OTD or OTDOA when all cost elements are considered. In addition, A-GPS offers a natural extension to Cell-ID for improved performance, suggesting that an effective hybrid deployment can be based on a combination of A-GPS plus Cell-ID for high accuracy and improved yield. A-GPS can also be combined with limited "spot" deployments of E-OTD or OTDOA. These combinations can provide the performance and flexibility of A-GPS and may help improve yield in limited areas of the network, while maintaining the overall cost/benefit to the operator (SnapTrack, 2003).

3.6 Java capabilities

According to ZDNet (ZDNet, 2002), in September 2002, 22 companies, including large mobile phone manufacturers finalised a version of Java designed for low-end, mainstream phones with low-powered processors and limited graphics. The result, the Java Mobile Information Device Profile (MIDP) for Java ME, is planned to be available in millions of handsets this year from manufacturers like Siemens, Nokia, Ericsson and Motorola. Thus it seems that most phones can adapt services like the GiMoDig in the near future. Presently Nokia has nine mobile phones that are Java enabled.

4 Classification of devices

The devices with graphic capabilities available on the market can roughly be classified in one of the following classes:

1 Mobile phones with WAP (Wireless Application Protocol)

This group of devices is characterized by:

- No options of adding software to the device that exceeds the software built-in by the manufacturer
- Small display, either black and white or greyscale although a few phones with colour display are available

The phones in this group will not be appropriate for the GiMoDig project. However many of the phones in this group have GRPS capability and could be used for some simple location-based services.

2 “Smart phones”

These are mobile phones equipped with a proper OS that gives the ability to upgrade the phones with add-ons from the manufacturer or third part vendors. This kind of phones must be considered the most appropriate for handheld devices for the GiMoDig project.

For the moment, there are only a few phones available on the European market that could be categorized as “Smart phones”. However, many vendors are announcing smart phones to come to the market during this year, but commonly the technical information are very slender, properly because of the competition on the market - there must be enough information to get the consumers curious, but not enough to let the competitors make countermeasures.

As both Nokia and Sony Ericsson are supporting the Symbian OS, this must be expected to be one of the major OSs on this market along with Microsoft's Smart phone OS.

3 PDAs with communication extensions

This group consists of small handheld computers, most often without a keyboard. The user is interacting with the device using function keys and a stylus. The type and functionality in the function keys varies from vendor to vendor, but most often, there will be some keys to navigate on the screen.

A table of further information on the categorisation of selected handheld devices can be seen in Appendix A and some pictures in Appendix C.

5 Conclusions on categorization of devices

At present, there are many changes going on in the mobile phone industry. The communication is changing from 2nd generation GSM technology through 2½ generation GPRS towards the 3rd generation UMTS. The most important issue, besides the increasing speed, is the use of packet-based communication available from 2½ generation GPRS and on, which allows much more sophisticated communication between the handheld device and the communication network, because the device can be continuously connected to the network. In that way the technology to be used in the GiMoDig project is available, thus not present in any mainstream mobile phone, only in a few combined PDAs and high end mobile phones.

Because of the small amount of capable handheld devices at present, it seems reasonable to take PDA's like Compaq iPaq with wireless expansions packs using GSM/GPRS in use during the initial phase of the GiMoDig project. This will still make it possible to establish a test environment on the handheld device that in many respects will be similar to what can be expected on mobile phones before the end of the project. If the Nokia Communicator smart phone had been able to use GPRS it could have been an obvious choice as well, especially because of the GPS-module available for the Communicator.

Part II

Cartographic design for small-display devices

1 Introduction

The primary focus of the work in Part II of this report is to study and develop cartographic principles suitable to be used for personal navigation purposes when devices with small displays are used. In a broader scope it can also be considered to be a part of multi-media (e.g. vision, audio, tactile) cartography for specific purposes, although the multi-media aspect are not studied here in depth.

The ideas presented in this part were discussed at the workshop on small-display cartography in Copenhagen, organized by the KMS, August 28-29, 2002. The goal of the workshop was to share a common base for the research and development of new kind of specialised cartography for small displays, to agree on the principles of the design on the cartography for small displays and to achieve a common understanding on the problems and solutions for the task.

In the following paragraphs we first discuss some basic concepts for cartographic design.

Introduction to cartography

A map is produced because someone has decided that there is a need for information to be transmitted. This purpose is rarely made explicit. However, such a purpose does become clear if the idea turned upside down and one tries to imagine someone producing a map 'just for fun' or merely because it could be a pleasure to own; (the production of a map is far too costly for that). The purpose of a map is always transmission of information!

Preparing transmission

Communication and the transmission of information do not just have to do with casting as much data as possible, with the greatest haste, in the face of the receiver (the user). Quite the opposite! Cartographic transmission of information requires careful preparation, which results in a selected and user orientated quantity of information. The following model in Figure 1 describes the transmission of cartographic information (Brodersen, 2001):



Figure 1. Transmission of cartographic information.

From the model above the fundamental elements of cartographic communication can be defined as - data, information and knowledge. This model also shows how we can, to a certain degree, measure the quality of a cartographic transmission on the basis of the user's experience of the map. Based on the model and considerations of the quality measurement, a method can be described for the producer's preparation of a concrete task. This method sets the user at the centre of the work process.

Generalisation

The definition of generalisation by the International Cartographic Association (ICA) was: "The selection and simplified representation of detail appropriate to the scale and/or purpose of a map" (ICA, 1973). Even the best-prepared cartographic transmission of information is under the influence of a concept, which we may call the 'cartographic uncertainty principle' because maps are media in a one-way communication. The object then, is to reduce this uncertainty as much as possible. In cartography generalisation is used as a tool to achieve this reduction. It is most important in this process that we limit the amount of information that is to be transferred so that there is just enough to enable the user to find the answer to his question. Not just an unconscious, mathematical reduction but rather, a purposeful and meticulous selection. If, hereafter, this small amount of necessary information is reproduced in an exaggerated fashion we will tend to achieve a communication, which is not encumbered with uncertainty. This must be the ultimate aim for every communication.

The aim of cartographic generalization is communication with the least possible uncertainty (in the shortest possible time). On the basis of the theory, generalization is divided into two parts; one part deals with the organisation of the informational content and the other with the arrangement of the graphic presentation.

The means of cartographic presentation

Graphics and symbols can be given various characteristics (attributes, distinctive features). Each of these graphic characteristics or attributes can emanate various values.

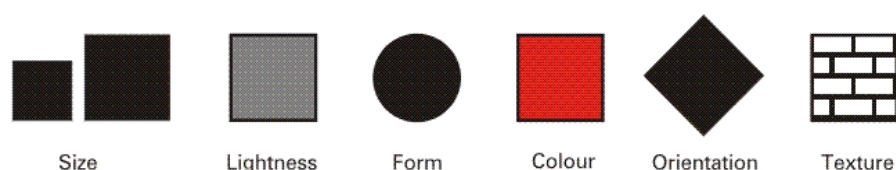


Figure 2. Graphic variables according to Bertin (1967).

In that we can vary these graphic characteristics, we can also speak of graphic variables (Bertin, 1967), Figure 2. It can be shown, from experience, that the various means the cartographer has at his disposal to create symbols, immediately brings about the same associations in most users. The lack of a formal language in cartography makes it important to have a firm understanding of the effects different graphic variables bring about, so that a correct and well functioning transmission can be achieved. For example, colour, which is employed heavily as a graphic resource, is generally perceived as something to do with groupings (families) whereas lightness is perceived as something to do with increasing or decreasing values. It is important to know about these associations (those which graphic variables generate) because by taking them into consideration the cartographer can create information, which is understood correctly by the user – which is

to say that he can produce information, which is understood in a particular, predetermined manner.

2 Assumptions

The proposed small display cartography will be based on a set of assumptions that will limit the scope of the project in terms of ambition, technology and user behaviour.

The desired cartography has to support the purpose, provide the aims and satisfy the user's requirements when being a foreign tourist in the city or travelling on a bike in the country. We have completed the work based on the following assumptions:

- End user with no or very little knowledge of maps and navigation. We anticipate that a mass market navigation service will show how few individuals are well known to maps and other kind of geo-information. Therefore the rather simple or humble ambition or approach.
- Small display with limited resolution and colour depth. Technical development will of course increase the span of screens capability, but for the next years the trendsetters only will renew their handheld devices rapidly.
- Interactive but no easy communication (incl. position). This is an assumption built on the expectations and experiences on the services provided today. Especially the telecommunication covering area and the GPS-receiving in the cities can cause trouble. We have no remedy at hand for this.
- Navigational tool for a slow traveller. A slow traveller is a traveller on foot, on a bike, on a tramp, on a city-train or a bus. Navigational aids for the motorised community are already available as in-car-navigation means.
- The study of small-display cartography will focus on meeting the requirements for a class of use cases: Slow travelling personal navigation aids by a small handheld device.

3 Technical preconditions

Due to the choices of technical preconditions made by the GiMoDig project, these restrictions, limitations and technologies has been framing the whole project together with the harmonised data sets, the system infrastructure mechanism (see Part III) and the software technologies chosen for the generalisation task purposes.

The technical preconditions for the work are as follows:

- A mobile phone or PDA constantly connected with the GPRS-telecommunication system. The handheld device is supposed to be put away in a pocket. A laptop computer could be regarded as handheld but is not normally suited for a pocket.
- Connected to a positional service (e.g. GPS) and a navigational service (e.g. GiMoDig). These dynamic services are essential for navigation. A pure static map stored in a handheld device will somewhat remedy the lacking functionality, but require a large memory and a map-using user.

- A colour screen display (down to 180 x 180 pixels on 45 x 45 mm) is chosen as the smallest functional display to a normal user. You can think of smaller screens, but the usefulness of such a screen must be marginal. We have tried to solve questions related to technology for a possible mass market.
- A narrow colour palette (256 colours of which 10 -12 can be used at one instance). This is a precondition that is very easy today to fulfil. The only real problem could be which of the 10 – 12 colours are available and usable.
- Interactive menu for selecting parameters, points of interest and choice of operation etc. We assume an interactive selection of needed and wanted information to be the primary design principle in the interface. This could be very important for the general user adoption of technology and connected services.
- Semi-interactive image showing information, map and sign graphics. Semi-interactive is a term for application driven communication with the user. E.g. when in navigation mode the application will update the map and keep the current position and possibly the destination inside the display and show the user how to proceed.
- Application capability to zoom, pan and being shown position, waypoint and destination. This is a client device requirement. The device will need to support a client application, which keeps track of the current position, the route to the destination and a possible set of waypoints in between. Furthermore a set of tools for mechanic zooming and panning could be nice.
- SVG (Scalable Vector Graphics) Tiny, Basic and Standard specification for low, medium and high end devices. SVG is chosen because it is a specification developed for general graphic presentation, based on XML like the GML (Geographic Markup Language) that is chosen as geodata extraction format. SVG and GML specifications are expected to be supported by all major vendors on the market.

4 Definitions

The report content references to some central terms, which are explained here:

- Small display is here defined as a raster based colour (better than 256 concurrent colours) display screen with a very little surface (down 180 x 180 pixels and 45 x 45 mm) and a resolution not better than 0.25 mm pixel size. Screens bigger than 360 x 360 (90 x 90 mm) pixels or with much higher resolution than mentioned will not be considered as small displays.
- Cartography is here defined as the design and layout of map objects and geo-information when used for navigational and tourist information purposes. Interactive cartography is the way an application can support navigation e.g. by moving the map when the user is moving around and support tourist information queries e.g. by giving a possibility to select and show attribute data to a map object.
- Navigation is here defined as the task and the solution to the problem of identifying a route between 2 points or places. E.g. from where you are at right now to the target or destination you are headed – either intermediate or final.
- Orientation is here defined as the human task and solution of assure yourself that you are where you believe you should be in terms of a place on a map as well as in reality. Thus, orientation is a subset of navigation.

- General framework for small display cartography is here defined as the modelled, symbolised and graphic rules, principles and recommendations for a specific cartographic application and specific handheld equipment to support a location based service.

5 Traditional cartography

5.1 Definition of cartography

Cartography was defined by the International Cartographic Association ICA in 1995: "A map is a symbolised image of geographical reality, representing selected features or characteristics, resulting from the creative effort of its author's execution of choices, and is designed for use when spatial relationships are of primary relevance." Cartography is the art of representing a model of the real world in a graphical way. Traditionally the cartography has aimed towards the paper, which is a high resolution and rather large extension media.

The task to create a map is dependant on the following facts:

- the purpose of the mapping or representation of information
- the target group with all their different experiences
- the user requirements and needs for various information and the mapping of these

You cannot expect to compose an ideal or universal map. Hence the task will be to limit and to specify a rather narrow purpose and goals for the map to be used.

Another way that the desired cartography in this work is different from the traditional one, is the way that it should support any resolution in terms of a zoom factor and still be readable.

5.2 Perception entities and media resolution

Some difficulties exist when considering some laws of nature. E.g. the way the human sight can perform and the way any transport media can "perform" in terms of resolution and light reflection. We neglect the reflection issue here.

- The human eye can in 30 cm's distance from the paper normally separate objects as close as 0.02 mm under normal light and contrast conditions
- The off-set paper printing resolution is around 0.04 mm
- The mainstream screen display resolution is around 0.25 mm pixel size

We thus infer that objects on a screen display shall lie at least one pixel away from each other if they do not coincide. And until the display technology reaches a resolution that is comparable to paper the distance between 2 objects will be 1 pixel. Later the distance will be represented with several pixels.

5.3 Graphic variables

Bertin (1967) presented the seven graphic variables, which form a way to consider the graphic communication in a convenient way to implement tools in order to support graphics on computers and other electronic equipment.

- Size (e.g. big, ..., medium, ..., small boxes)
- Colour (e.g. red, orange, yellow, green, blue, ...)
- Form (e.g. rectangle, triangle, circle, cross, ...)
- Density (e.g. black, dark grey, light grey, ..., white)
- Structure (e.g. waves, bricks, dots, ...)
- Direction (e.g. rotated 0, 10, 19, 28, 37, 46 degree)
- Position (cannot be used: fixed position)

As can be seen the attributes types are known from implementations of graphic support. For example, the sizes are handled in SVG-specifications as width and height. The colours are handled as RGB-encodings and as enumerable attribute-names. The geometric forms are supported by geometric primitive-functions and patterns and structures can be reached by raster-images.

6 Map reading

An important point is to define what is understood by 'good map reading'. The ultimate aim for the producer of a map is that his map affords the user a possibility to get quick and reliable answers to relevant questions. This definition does only apply to 'structured information search' with a given aim. It does not apply to a so-called 'encyclopaedia search' where it is unknown from the beginning what the aim is. The keywords for this structured information search definition are 'quick', 'reliable' and 'correct answers'.

The appropriate measures in an attempt to quantify these three terms could be the following criterion of success:

- Correct (number of percentage of correct answers)
- Safe (reliability: mental and visual behaviour, and)
- Time (quick: time used to solve the task)

At this stage these criterions have not been tested satisfactory. Therefore they will until further research has been carried out remain as postulate. However, if the postulate is stood on its head it becomes clear that it seems to be the obvious way of assessing map reading. None would ever appreciate incorrectness, slowness and uncertainty.

Brodersen et al. studied a method for measuring map readability on a small population without formal knowledge and skills on topographic maps. Figure 3 shows the results from the study on map observation (Brodersen et al., 2002).

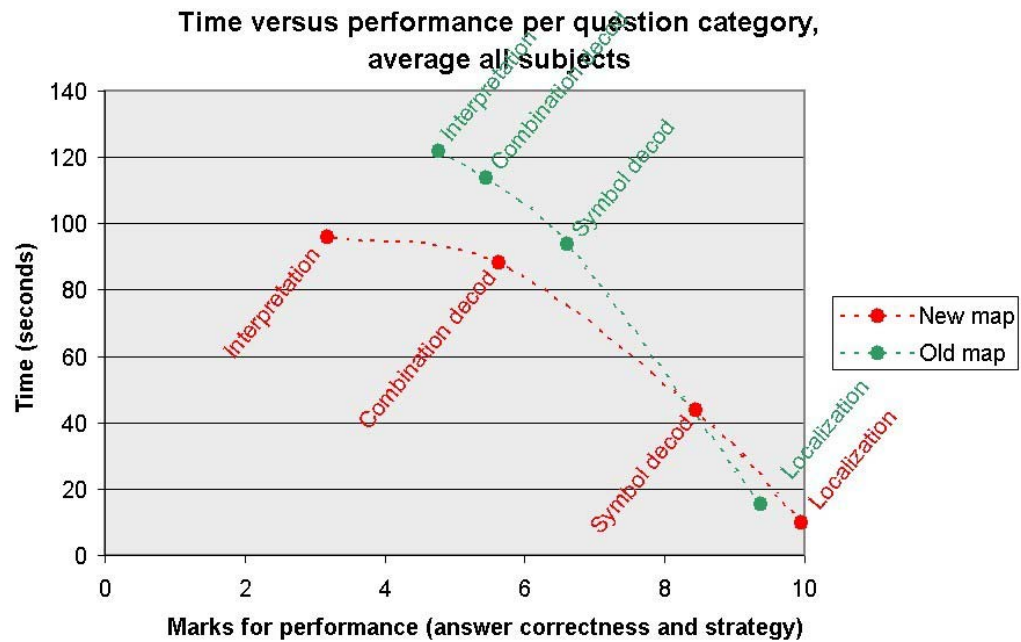


Figure 3. Correlation between question, time, performance, new and old map.

This figure is most interesting as it shows a clear tendency to linear correlation between 'time spend' and 'performance', as the difficulty of the questions is being increased - in some respects quite big. On the other hand, it is remarkable how linear the question categories are positioned. With no correlation the points would have been spread widely over the entire diagram and not ordered accordingly to difficulty.

What we see here could, maybe, be interpreted as a 'standard slope' for each map type. This could, if it is so, be used as an indication of what level of difficulty can be handled with satisfactory performance on that particular map type.

It could be most interesting to investigate more design types to see if this picture of lines with different slopes would be repeated or rather extended.

7 Font entities

Text is an important feature of a map regardless whether it is a paper or an electronic display. There are a huge variety of different forms and designs of text fonts that enable the (map) application for specific purposes. The fonts are classified in families that group similar functions and hence their purposes (Imhof, 1975).

The font-families can roughly be classified this way:

- Antiqua used for text in printed books
- Grotesque used as general block texts
- *Kaligraphy* used as hand writing text

- Decoratives used as headlines and sign text
- Gothic used as old printed books
- Egyptienne used as elder decorative font text

It should be clear that the grotesque font family has some advantages when considering our special objective. The lack of ornamentation and small details makes the grotesque font simple and rather easy to map and represent on a computer screen. It could be argued that the font is too simple and misses “personality”, but here priorities the functionality: easy perceived and therefore readable.

The general font attributes can be listed as:

- Font family (e.g. Antiqua)
- Outline (e.g. Opaque)
- Direction (e.g. Italic)
- Size (e.g. 12 pts, double spacing)
- Colour (e.g. grey)
- Strength (e.g. bold)
- Width (e.g. normal)
- Versal (e.g. Capital)

In order to optimise the usefulness and understanding we have chosen the grotesque font family in our study to be used in small displays of mobile devices. Depending on the device capabilities one can choose e.g. Arial or Verdana etc. They are fonts easy to read and well suited for electronic screens almost always based on raster-pixel representation. For example, the Arial font exists in a handful of varieties, e.g. Narrow, Black, Unicode MS etc.

8 Use cases

In the following Sections 8.1 and 8.2 we describe two different use cases that have been used as examples for our work on small display cartography, see also Jakobsson (2002).

8.1 Use case 1: A tourist in an unknown city

Target group

As a target group we think of pedestrians, pedestrians using public transportation, bicyclists and other non-motorists in a city. Normal, healthy people between ten and retired who want to get to, navigate to a destination and cover 80% of average, normal citizens. Disabled people's navigation is an important issue, however, it is not considered here.

Use model

The user starts out thinking: 'I want to find Place X' or 'I need to find Place X', and he switches on the device.

The device initialises and locates itself automatically.

The user is confronted with a first question: 'Where do you want to go?' followed by a list of themes (e.g. address, points of interest, health, safety, transportation, have fun, shopping etc.) and the choice of 'point out on map'.

The user navigates through the thematic lists (the list of 'points of interests' could consist of a sub-list 'museums, parks, restaurants, amusement parks, churches, memorials etc.). Choosing e.g. the item 'museums' results in a new list consisting the names of all museums in the vicinity. From this list the user selects the intended object.

In case the user doesn't know the name of the object he will have the choice of pointing out an object on a map (e.g. the nearest riverbank).

Parallel to the first question ('Where do you want to go?') the user will have the choice of 'Save present position' – followed by 'Naming present position' (and the user types in 'car' or 'wife' or similar).

When the user has selected an object, it will be displayed on the background of a map to give the user the opportunity to check if it is the right object. If the user decides it's the right one, she selects 'okay – continue', otherwise 'adjust route' or 'no – start over'.

In case of 'okay – continue' is chosen, the device calculates the route from present position (even if it's not saved) to the selected object. The route will be presented on a map and the distance along the route is displayed.

According to the configuration (see below) the device switches to mode 'step by step', 'traditional map' or 'bird's-eye view' as soon as the user starts moving.

If the user starts out in a wrong direction the device will immediately warn her 'wrong direction – turn around' (or similar).

As long as the user moves along the desired route the device automatically recalculates the route regarding remaining distance and estimated time arrival (according to actual speed).

If the user misses the route the device automatically recalculates the route and gives the warning 'original route has been left – new route is being calculated'.

In case of 'adjust route' the user is being given the choice of selecting waypoints (from the standard lists of objects or a saved 'present position'). The user will have to decide the order of which the selected objects should be visited.

In case of 'no – start over' everything starts over.

In the configuration mode the user will have the opportunity of choosing between user modes 'standard', 'advanced' and 'nerd'. Each of these user modes will have its own selection of facilities presented to the user.

In the configuration mode the user will also have the choice of three ways of 'map presentation'; 'step by step' which means arrows and simple directions, 'traditional map' or a map displayed in a bird's-eye view. Other settings should be considered.

User functions

In Table 1 the main user functions for Use case1 are listed.

Table1. User functions for Use case 1

Main functions	User's interface	System functions
Configuration not mandatory	(Not mandatory)	
Identify object thematic lists	Select from a list	Thematic lists (addresses, points of interests, railway stations, hospitals etc.)
	Or point out on a map	Create temporary object incl. naming
	Or create object	Save present position incl. naming
Locate object	Display object on a map	
	'Check'	Continue, edit/adjust or start over
Route (A,B)	Display route on map	Automatically calculate route and display
	'Check'	Continue, edit/adjust or start over
Edit waypoints	Change route?	Edit/insert waypoints, edit object
Step-by-step Traditional map Bird's view	Select route display mode	Step by step showing remaining route
		Traditional map showing remaining route
		Bird's-eye view showing remaining route

Criterion for success

A normal twelve years old child or her grand mother between sixty and seventy must by herself be able to find her way to any destination, within the initially calculated timeframe plus 50%.

Preconditions

The device is not to be used in known areas (areas where the user knows where 'everything' is and how to find it).

The user should have the choice between two or three user profiles (standard, advanced, nerd). The standard profile leaves only a few choices for the user (the trouble shooter device), e.g. a choice of map display. The advanced and nerd profiles present more choices and functionalities (the detour adviser device), e.g. 'Create a pub crawl route within given limitations'. This has to be refined.

Destinations should be: Geo-referenced objects as e.g. addresses, sights, restaurants, junctions, transportation nodes and starting point. Objects should be presented with both

their names as well as their category ('restaurant' and 'The Old Tavern'). In case the device is being used in an area without geo-referenced objects the user should be given the option of selecting an object from the map.

The device should automatically re-calculate the route during the trip. However, it should be possible to press an 'update button', if one is doubtful about the sensibility of progress.

Is this device an effective trouble-shooter or is it a detour inspiration assistant? We choose something in between. The user should have an option to choose 'more detour assistance' or more 'trouble-shooter', e.g. plus-minus 20% from default.

Interaction: Maybe it should be part of the configuration how much the user wants to control, or should be able to control the device's calculations, information etc. One extreme is that the user trusts the device fully and simply follows the directions one by one (single dimensionally navigation). The other extreme is, that the user does not trust the device and wants to check the directions e.g. by studying a map (multi dimensionally navigation).

The user should have the possibility to save 'present position' ('I want to find my car again'), as well as other waypoints ('my wife is waiting here'). This facility should be available for actual positions only (present position), and not for remote positions; this is to avoid misinformation caused by false coordinates.

Directions should be given audio visually, i.e. by maps and arrows supplemented with speak. It should be an option to de-choose one or the other. This approach forces the user to use an earplug while listening and looking at the same time.

One could imagine the following three scenarios how to present the map or the navigation directions:

- Directions as arrows to the right, the left, straight forward etc.
- Moving map (up, down, right, left) with the actual position in the middle.
- Maps presented in bird's-eye view and oriented towards the destination.

We assume that the user and the device agree that they know where they are at the beginning of the trip, or that the user basically trusts the device's capability to locate itself.

Facts to consider

The following facts should be considered in our development of small display cartography:

- Is it a problem having two systems? One in the car and one hand held. The old grandmother might have problems with that.
- Docking station in the car?
- What about language if audio is implemented? Everybody might expect the device to speak 'my own language' as well as English when used in foreign countries (as tourist in e.g. Madrid).
- Logging and transmission of position to another device (or home base). For the consideration of 'Where is my wife?' and similar safety precautions.

8.2 Use case 2: A bicycle family holiday in the countryside

Target group

As a target group for this use case is a family with children on a bicycle holiday.

Scope

A family with children has planned a combined bicycle and camping trip for the summer. Using a public map service, they have planned a suitable route for each day and located convenient camping sites. They intend to go by bicycle avoiding the major roads and looking nice places to go. They have bought mobile devices so that their relatives at home will be able to track the family's location. They also plan to use these mobile devices for navigation to e.g. amusement parks. They plan to locate places of interest with the help of the mobile devices and to save addresses of other locations they expect to meet on the trip. Further, they want to have the all-possible camping sites and hotels along the route, for the case they want change their plans. The father is an enthusiastic bird watcher, so he also uses a bird watcher alarm to get notified when interesting appearances occur, and where it is.

Use model

The task is to find the way to Place X. The user starts out thinking: 'I want to find Place X' or 'I need to find Place X', and he switches on the device.

The device initialises and locates itself automatically.

The user is confronted with a first question: 'Where do you want to go?' followed by a list of themes (e.g. address, camping site, points of interest, health, safety, bicycle repairer, shopping etc.) and the choice of 'point out destination on map'.

The user navigates through the thematic lists (list of 'points of interests' could consist of a sub-list 'museums, parks, restaurants, amusement parks, churches, memorials etc.). Choosing e.g. the item 'museums' results in a new list consisting the names of all museums in the vicinity. From this list the user selects the intended object.

In case the user doesn't know the name of the object he will have the choice of pointing out an object on a map (e.g. the nearest riverbank).

Parallel to the first question ('Where do you want to go?') the user will have the choice of 'Save present position' – followed by 'Naming present position' (and the user types in 'tent', 'wife' or similar).

When the user has selected an object, it will be displayed on the background of a map to give the user the opportunity to check if it is the right object. If the user decides it's the right one, he selects 'okay – continue', otherwise 'adjust route' or 'no – start over'

In case of 'okay – continue' is chosen, the device calculates the route from present position (even if it's not saved) to the selected object. The route will be presented on a map and the distance along the route is displayed.

According to the configuration (see below) the device switches to mode 'step by step', 'traditional map' or 'bird's-eye view' as soon as the user starts moving.

If the user starts out in a wrong direction the device will immediately warn him, 'wrong direction – turn around' (or similar).

As long as the user moves along the desired route the device automatically recalculates the route regarding remaining distance and estimated time arrival (according to actual speed).

If the user misses the route the device automatically recalculates the route and gives the warning 'original route has been left – new route is being calculated'.

In case of 'adjust route' the user is being given the choice of selecting waypoints (from the standard lists of objects or a saved 'present position'). The user will have to decide the order of which the selected objects should be visited.

In case of 'no – start over' everything starts over.

In the configuration mode the user will have the opportunity of choosing between user modes 'standard', 'advanced' and 'nerd'. Each of these user modes will have its own selection of facilities presented to the user.

In the configuration mode the user will also have the choice of three ways of 'map presentation'; 'step by step' which means arrows and simple directions, 'traditional map' or a map displayed in a bird's-eye view. Other settings should be considered.

Get notification on interesting occurrence

The user is subscribes to a 'birds watcher notification' news group. The idea is that all users of the group send a message to the database, that e.g. 200 golden eagles have been observed at certain location. This location is defined as the observer's position given by his device's location facility.

All subscribers present within, say 50 km from the observation location get notified on their mobile device through a small text and a symbol on the map.

From there, the user (in this case the father) acts as if he was searching the route to a museum, see above.

Keeping track of each other

The user subscribes to a 'keep track of somebody else' news group. When the user wants to activate his subscription, he sends a request to the database that he (A) wants to receive information (i.e. the location) of a certain person's mobile device (B). The request is forwarded to B, 'is it okay to let A know where you are? Yes or no?' If B answers yes his position is transmitted to A's mobile device and shown on A's map with a particular symbol.

User functions

In Table 2 the main user functions for Use case1 are listed.

Table2. User functions for Use case 2

Main functions	User's interface	System functions
Configuration not mandatory	(Not mandatory)	

Identify object thematic lists	Select from a list	Thematic lists (addresses, points of interests, railway stations, hospitals etc.)
	Or point out on a map	Create temporary object incl. naming
	Or create object	Save present position incl. naming
Locate object	Display object on a map	
	'Check'	Continue, edit/adjust or start over
Route (A,B)	Display route on map	Automatically calculate route and display
Edit waypoints	'Check'	Continue, edit/adjust or start over
	Change route?	Edit/insert waypoints, edit object
Step-by-step Traditional map Bird's view	Select route display mode	Step by step showing remaining route
		Traditional map showing remaining route
		Bird's-eye view showing remaining route

Criterion for success

A normal fifteen to thirty years old bicyclist must by himself be able to find his way to any destination, within the initially calculated timeframe plus 50%.

Preconditions

The device is not to be used in known areas (areas where the user knows where 'everything' is and how to find it).

The user should have the choice of two or three user profiles (standard, advanced, nerd). The standard profile leaves only a few choices for the user (the trouble-shooter device), e.g. a choice of map display. The advanced and nerd profiles present more choices and functionalities (the detour-adviser device), e.g. 'Create a pub crawl route within given limitations'. This has to be refined.

The question is whether the device is an effective trouble-shooter or is it a detour inspiration assistant? We choose something in between. The user should have an option to choose 'more detour assistance' or more 'trouble-shooter', e.g. plus-minus 20% from default.

Destinations should be: Geo-referenced objects as e.g. addresses, sights, restaurants, junctions, and camping sites. Objects should be presented with both their names as well as their category ('restaurant' and 'The Old Tavern'). In case the device is being used in an area without geo-referenced objects the user should be given the option of selecting an object from the map.

The device should automatically re-calculate the route during the trip. However, it should be possible at any time to press an 'update button', if one is doubtful about the sensibility of progress.

Interaction: Maybe it should be part of the configuration how much the user wants to control, or should be able to control the device's calculations, information etc. One extreme is that the user trusts the device fully and simply follows the directions one by one (single dimensionally navigation). The other extreme is, that the user does not trust the device and wants to check the directions e.g. by studying a map (multi dimensionally navigation).

The user should have the possibility to save 'present position' ('I want to find my car again'), as well as other waypoints ('my wife is waiting here'). This facility should be available for actual positions only (present position), and not for remote positions; this is to avoid misinformation caused by false coordinates.

Directions should be given audio visually, i.e. by maps and arrows supplemented with speak. It should be an option to de-choose one or the other. This approach forces the user to use an earplug while listening and looking at the same time.

One could imagine three scenarios how to present the map or the navigation directions:

- Directions as arrows to the right, the left, straight forward etc.
- Moving map (up, down, right, left) with the actual position in the middle.
- Maps presented in bird's-eye view and oriented towards the destination.

In any case, maps of scale 1:100 000 and 1:200 000, which are the traditional scales for bicyclists, are the inspiration for the maps in this study. This 'scale' or resolution will also reduce the need for precise location, i.e. cell-based location could be satisfactory.

We assume that the user and the device agree that they know where they are at the beginning of the trip, or that the user basically trusts the device's capability to locate itself.

Navigation

Navigation might take place on different levels of abstraction. One is the overall targeting (macro navigation), another is the next step (micro navigation).

How much of the map is to be shown on the screen? How often is the map to be updated on the screen? One possibility could be to show the map between two geo-referenced waypoints (e.g. from one street to the next street), or maybe the nearest geo-referenced waypoint, the next one as well as a third waypoint along the route. According to this the map should be updated on the screen as soon as the user gets closer to the next waypoint as to the previous waypoint.

Facts to consider

The following facts should be considered in our development of small display cartography:

- What about language if audio is implemented? Everybody might expect the device to speak 'my own language' as well as English when used in foreign countries (as tourist in e.g. Madrid).
- Logging and transmission of position to another device (or home base). For the consideration of 'Where is my wife?' and similar safety precautions.

9 Proposal for a cartographic solution

The cartography to be designed is created especially for small mobile displays with a relative poor resolution. Furthermore the criterions will be based on the expected knowledge and behaviour of an average end user not used to handle maps and tools for navigation.

Several studies have been made in order to investigate the challenges on the cartographic concepts and conditions (Uhlirz, 2002) and (Hardy et al., 2001).

We make the following proposal for the basic ideas and principles to be applied in the small display cartography applications:

1. Four (4) layers of stacked symbolologies:
 - Text in exclusive colour: black
 - Navigation elements in exclusive colour: yellow with red stroke
 - Points of interest (POIs) in exclusive colour: dark blue
 - Map (backdrop) in bright colours not including the colours: black, yellow, dark blue
2. Few details
3. Pictogram-like symbols
4. A font type with no ornamentation
5. Adopted to the SVG-specification (Tiny, Basic and Standard) as a precondition

The small display cartography used in this work should cover all relevant object types that exist in (Northern) Europe. The different landscapes in Europe should be represented in harmonised (in terms of colour, pattern and details) cartographic elements.

The text should be easy to read and easy referable to the object. In general text elements are to be situated in the horizontal level, but street names and watercourse names should be rotated along the main direction of the object. The text elements should be scaleless, e.g. the same scale independent of view port, but filtered through the resolutions (scale intervals) in number and importance.

The POI-symbol should be based on every day met signs in the street and other places and therefore in a way familiar to people. They should ideally recognise these signs from reality in the map on the handheld device. Because of the possible crowded area in terms of POI in the centre of the cities the POI-symbols should be removed away from the “real” spot and connected with a thin dark blue line. The symbols should be scaleless, e.g. the same scale independent of viewport, but filtered in number through the resolutions.

The cartography should ideally integrate the different existing cartographic and navigational cultures existing in Europe. The different way to symbolise features like public toilets, camp sites and phone boxes is a challenge to harmonise in an easy understood yet simple way to depict these pictogram-like symbols on a map.

9.1 Navigation

The overall purpose is navigation in an environment that is supposed to support personal “slow” movements in an unknown terrain. These slow movements could be walking, biking, hiking, to go by tram and the like. One could also imagine a known terrain with unknown points of interest to explore.

To navigate one needs to know a number of things:

- Where do I start (and how to start the application)
- Where I am right now (position service)
- Where I am headed (direction, eventually towards waypoints)
- Where do I stop (destination, eventually waypoints)
- How to come from start to destination (route calculation)
- What to expect to see during the route (kind of self assurance)
- How to input the destination, waypoints and other POIs (not cartography)

The navigation purpose has two extreme and upper sit aspects: the “problem-solver” at one end and the “detour-assistant” at the other. The latter one is a navigational tool for a traveller who wants to be lead astray e.g. by desired near by POIs and the former is the pure help to find the shortest or fastest route to the destination with no detours.

Most of that information will lead to a cartography that is more suited for navigation than for other purposes regarding map reading and maybe map analysis.

The most important thing to know when navigating is to match objects on the map with corresponding objects in reality. It is the easiest task to match objects that has a name attached – both in the map and in reality. These references are street names, place names and other kind of object names e.g. names on a rail station, bus stop or even names on buildings.

We will from hereon depict these objects as geo-referenced objects. (Excursion: Large buildings in Greenland were during second world war with a unique id-number on top of the roof in very big figurers. Every air pilot looking at this unique identifier was pleased to know exactly where he was according to a reference table.)

When several layers of symbologies are to be stacked on each other the text elements must be on top of all other layers on the navigation tool.

To orientate you will have to know where you are in any instant. The obsolete way to do it is to follow the map and the terrain and all the time keep track on where you are on the map. The modern way to navigate is to connect your electronic map (handheld device) to a positioning service that will detect your position (or others) in a more or less precise resolution. The user does in principle not need to know the position. In principle the user's needs are being satisfied with information on what action to do to reach next waypoint on the route, and at that point, what is the next action. It can be argued that additional information can be required in two circumstances, one if the person needs detour-assistance, two if the person requires safety-information (‘I’m on the right route and I need to be confirmed about this every five minutes’).

These navigation symbologies elements can be seen as the next most important layer possibly represented in its own exclusive colour or pattern.

When using the navigational tool you will rather soon require input and search facility for addresses, sights, traffic junctions and other points of interests that will extend the basic functionality of navigation. POIs is the term for objects that normally is not part of a topographical map, but in the context of navigation in an unknown environment, you want to know all what is worth knowing in the area of interest.

These POI-symbologies can be considered as a separate layer possibly represented in its own exclusive colour or pattern as the layer on top of the map reference layer.

The bottom layer is the map reference layer. Even if rather large space is used on text, navigation signs and POI-symbols most of the information should be transparent through the layers, although it will not be possible in general. We have later been forced to redraw the transparency demand due to the unwanted pale colours that remains.

The map reference is the bottom layer and is considered as a backdrop when using as a navigation tool.

Showing where you are, where you are heading and where you are bound is the core navigation task. The map showing the unknown terrain is merely shown for the purpose of you to keep track of distances, time and reassure yourself that the system is still working. Maybe you will find time and fun in going astray from the route, being sure to continue the route or to get the new route recalculated.

10 Considerations on content for personal navigation

In order to specify the cartography in question we have to consider how the content has to be generalised. The generalisation task consists of 3 elements:

1. The rules to select specific object types
2. The rules to select adequate sized objects (large objects relative to the scale)
3. The rules to derive objects from the source to a possibly new portrayal form

The rules to select specific objects and the minimum size are based on how much information can be showed on a map screen.

The amount of total objects you can comprehend without missing the overall understanding of the terrain is hard to define. But the chosen cartographic idea is to minimize the map content while letting the positional and navigational system do the hard job of keeping track of where you are. (Excursion: A study on human map reading resulted in a human “mental bandwidth” to be 1 (one) bit (Brodersen et al., 2002)).

The rule of prioritising the selection of object types says: firstly the navigational object types is selected, secondly the POI object types is selected, thirdly the navigation related recognisable object types and lastly the decor object types is selected.

The rules to derive objects from the source to a new (generalised) form are another task outside the scope of the WP3 project. This task will be dealt with in work package 7 (WP7) of the GiMoDig project.

10.1 Object size

The minimum size of objects is connected closely to the minimum size of the eyes ability to separate close lying objects, the resolution of the media and the overall idea not to put too many objects into the map screen.

The minimum size of area object types are defined to 8 x 4 pixels, except buildings in outline as template which minimum size is defined to 4 x 2 pixels.

The minimum size of linear object types is defined to 10 x 1 pixel.

The minimum size of point object types is defined to 3 x 3 pixels. (of which there are currently none or otherwise depicted with a POI-symbol)

10.2 Zooming, panning and data density

It is assumed that the dynamic zooming and panning is done by server requests. Static zooming and panning is provided by the client. Static zooming in is a mechanic increasing in object size in natural scale. No further details will be shown. A static zooming out without zooming in before will launch a dynamic new view with appropriate selection and generalisation.

An aspect concerning the way some other kind of applications could require a predefined data classification can be considered. One could imagine a professional application that requires a lot of attribute data and therefore the need to minimize the map canvas expressed as many object types.

11 Cartographic design-elements

The most powerful styling element is the colour. Because of the expected intuitive way the user is supposed to connect the map object colour to the real world phenomenon we choose colours as contrast full as possible to each other, yet at the same time as close as the colours of e.g. forest, marsh, crops and grass will appear in the nature. Of course this will not be true in all instances but the feel and touch should give the user a clue what it is all about.

The navigation signs and the colours have been thought of as an overlay – an artificial theme so to speak in an eye catching yellow with red strokes to sharpen the shape, while the POI-symbols and the colour used are frequently seen on maps. These POI-objects are subject to many different graphic designs for different map purposes. We have chosen a dark blue frame, inside a symbol upon a white canvas.

The line objects should be easy recognisable as: roads, contour lines, railways, watercourses and borderlines whilst having their own geometric attributes as straight, waved, meandering and irregular profiles. The colour should then give the last deciding clue to the line objects.

The outline description for the specific small display cartography is defined below. The exact specification is given in Appendix D. The colours will be defined in RGB-format as SVG-colours. Also the dashing of lines will be defined accordingly to the SVG-format. The symbols will be represented in a local coordinate system, thus enabling a handy reference to a global reference-system.

- Location names: black Arial / Verdana font-family, font-size: 12, 18 and 24 pixels
- Navigation: yellow /red stroke, width 1 pixel: arrow, triangle, circle, star
- Point of interest: dark blue frame with a dark blue symbol on a white opaque canvas
- Roads: red centre line
- Buildings: dark grey surface
- Lakes/ponds/waters: cyan surface
- Watercourses / shoreline: blue centre line
- Footpaths: brown centre dashed line
- Railways: grey single line,
- Build-up area: light grey surface
- Contour lines: light brown (centre) line
- Forest: green surface
- Marsh/swamp/wetland: greyish blue surface
- Grassland: light pastel green surface
- Cropland: green-yellow surface
- Administrative boundary: grey (centre) line
- Airport/air field: light orange surface

The object types defined in WP6 “Global Schema” are used as a basis for defining the small display cartography. It is of course a subset of a general set of object types. A European set of different object types will extend the cartography to include several types of landscapes local to different corners of Europe. As an example we could easily mention different forms of wasteland: rocky areas, glaciers, moors and dunes that are not included in the global schema of the GiMoDig project.

The shape and nature of the navigation sign is chosen due to the general and conventional use of arrows as direction sign, star as a fix point to go (the star of Bethlehem), the circle as a often used representation of “here-you-are” on local site plans and the triangle was chosen as a way sailors often meet “traffic” sign at sea.

The shape and nature of the POI-symbols were aimed to be similar with the known existing symbols in Europe, applied to the limited size and resolution of the symbol template.

11.1 Examples



Figure 4. A sample of Danish area presented on a map applying navigational cartography with POIs.

If we look at the map shown in Figure 4 the area is firstly too large as it is supposed to be viewed on a small handheld device, probably not bigger than 45 x 45 mm. Secondly this drawing will not justify the clearness, colour representation that can be seen on a real PDA or phone. Thirdly the location names (street names) should have been rotated along the objects (roads), but were decided to be placed horizontal due to the test phone's limited capabilities in this aspect. Fourthly the areas underneath the roads are not crop areas but due to missing data, all areas with no land use attributes are depicted as cropland. The Danish mapping specifications do not define cropland as a feature due to the complete definition of the remaining topographic objects. (Everything else is crop – like in Finland where everything else is forest.) Fifthly, the POI-symbols are not the latest version.



Figure 5. A city map of Copenhagen showing a route from the central station to a hotel.

The map is based on the general topographic database: TOP10DK.

Figure 5 shows another example, where a city map of Copenhagen shows a route from the central station to a hotel. In the example the routing signs and the POI-signs are not the final ones. The sample shows an extract much bigger than can be visible on a small handheld device. The location names are too few and should rather have been placed outside the road centre line. Note, that the printed colours are not comparable to additive RGB-colours in this sample.

The following yields the example shown in Figure 5:

Purpose:	A personal navigation task as a tourist in a unknown city
User groups:	Individuals on business or tourist travel in a big city
Aim:	Small display maps for handheld device for personal navigation and tourist and traffic information
Use case:	A tourist (or businessman) in an unknown city

A couple of tests on cartographic design aspects were made during this study. Figures 6 and 7 show some samples on these.

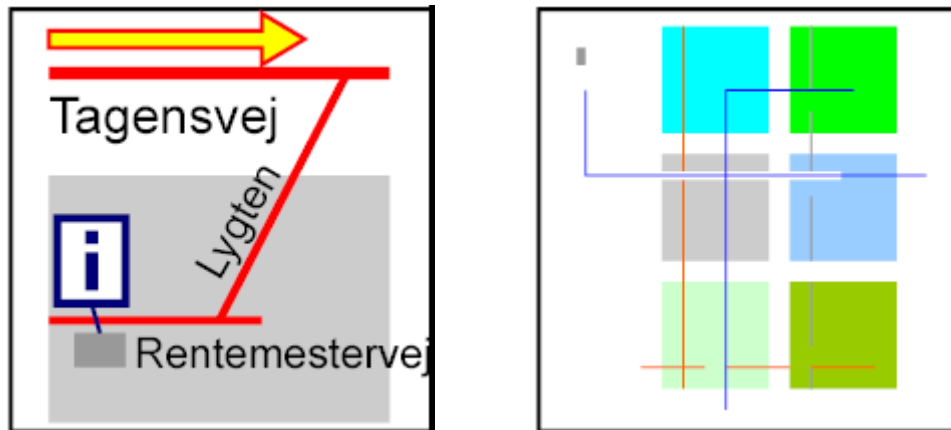


Figure 6. The placement of text and signs. Figure 7. A colour contrast study.

The upper part in Figure 6 shows that the placement of navigation sign and location name are preferably situated on each side of the road and the lower part illustrates the placement of POI sign referring to a building on the other side of the road. The location names should only be put inside a road if the scale permits it (is large enough).

Figure 7 shows a colour contrast comparison study as well as a study on how narrow and small object should be. Observe the white canvas below a blue line has surprisingly no convincing effect on the readability between this blue line and the greyish blue shape. The (vertical dashed) grey boundary line is hard to read anyhow.



Figure 8. An early design study for a cartography for “A bicycle tourist in the countryside”.

The idea is to reduce the content to a very minimum, just adequate for navigation.

Figure 8 shows an early design study of how to represent point of interests, the generalisation factor and if, why or how one can look through navigational signs and POI-symbols. All the symbols have been modified – with a general frame around – among other things. The following yields the example shown in Figure 8:

Purpose:	Personal navigation and a Location Based Service of “Birds watch”
User groups:	Families on holiday possibly on bikes
Aim:	Small display maps for handheld devices including selected tourist information and LBS, < 12 colours, 160x240 pixels
Use case:	A bicycle family holiday in the countryside

12 Conclusions on cartographic design

The work on designing an application-dependant cartography for the use cases “A tourist in unknown city” and “A bicycle family holiday in the countryside” has been carried out during 2002. A couple of important issues on how to use, design, implement and utilise future mobile information services have been identified during our work.

The work has focused on defining use cases, the assumed way of operating, when identifying important operational issues and on the main task of layout and designing a cartography for personal navigation aid for small handheld devices.

A workshop has been arranged in order to gather the consortium members together to discuss the basic ideas and general problems given operating an information system, interpreting the answers and keeping track of how to navigate and visualise the surroundings around us.

The initial cartographic ideas have been adjusted to the specified task. The central results are the information layer structure in terms of stacking the elements on top of each other, the choice of surface colours and line styles, the minimum size of selected objects and rules on how the elements are situated around each other.

The text style is an important feature that has been object to a great deal of investigation. The work on designing the symbols for POIs has been growing due to the optimisation of the shapes and different European cultures and habits.

It is quite clear that further investigations and testing especially in real nature is necessary while assessing how useful a specific cartographic application and its user will behave in every day life.

We suggest that the presented proposal should be tested, adjusted and further developed using several visualisation techniques available in the context of SVG and viewing facilities on a mobile device.

We are aware that even the best location based service will suffer if the user interface and the user understanding of the modelled geography are not sufficient.

As can be seen from Figures 9 and 10 below (in true scale) a high resolution photo of the test device reveals results, which are considered rather promising.

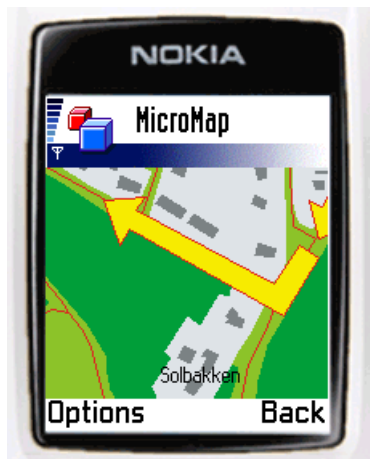


Figure 9. Test of cartography on a test device.

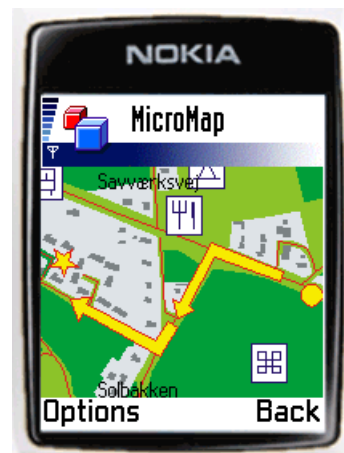


Figure 10. The same zoomed out.

Figures 9 and 10 (in true scale) show a SVG-file rendered on a Nokia 7650 phone supported by the Java Micro Development Environment. This device offers some menu-facilities in the bottom of the screen that can be used for communicating with the service. The other buttons on the phone could be activated in connection with operating the GiMoDig-service. The red lines are road centre lines and strokes on the navigation signs.

Part III

Study on the GiMoDig client – portal service communication

1 The purpose and overview of the specification

This part of the report is an investigation of the protocol to be used in the two-way communication between a GiMoDig client application and the GiMoDig portal service – two upper layers in the proposed GiMoDig system architecture, Figure 11. This protocol concentrates on parameters needed in formulating a map query to be transmitted from a mobile device to the portal service.

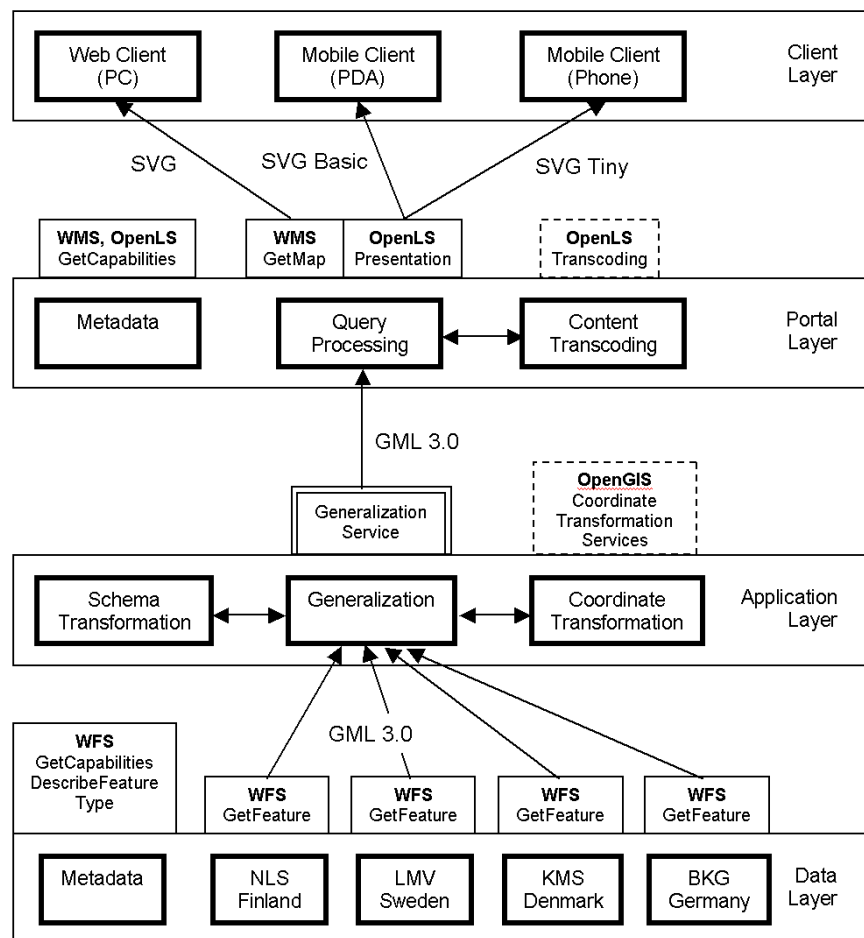


Figure 11. Preliminary system architecture (Lehto, 2002).

2 Assumptions

For the purposes of the protocol design we make the following general assumptions:

- The user of the service is an average user with no preference for using fancy settings and functions (although the protocol must leave space for this).
- The device is running GPRS or “better”, with other words the device is online all the time, and the service is being paid pr transaction or request.
- We are not concerned about how the device gets information from the positioning system about its location.
- The user device already has made contact to the GiMoDig service including giving identification for invoicing purposes.
- The user wants to have a “stop” button, to stop the system installed on his device from requesting more services than needed, in order to minimize his expenses.
- The Java application running on the client device will have a number of functions, which are completed locally without any communication to the server, e.g. zooming.
- The server/the portal service runs in a stateless mode, and has no information about the state of requesting devices.

3 Introduction to the map request information set

In the premises for GiMoDig WP4 is stated, that the client must be capable of running Java (Java ME - MIPD) applications.

Distributed applications communicating via the Internet is now being standardized to use XML. Hence this specification is also XML based. In general capital and small letters are distinguished in XML documents, therefore this specification also does. This implies that an XML document element or attribute will not be capitalized as the first word in a sentence.

This specification is inspired by the “Point of Interest eXchange Language Specification” abbreviated POIX (POIX, 1999). The specification describes an XML Schema containing all relevant information to be sent from a handheld device to the server, and to some extend also the information sent from the server to the device. An exemplary model for the client-portal map request is presented as XML schema in GiMoDig_MapQuery.xsd, see Appendix E.

The information sent from the handheld device to the server can contain the following blocks:

Device configuration information

- Device category (dumb, smart etc.)
- Reference information (datum & projection)

- Cartography mode (birdsEyeView, movingMap, stepByStep)
- User goal
- Map (type and scale)
- Positioning technology (GPS or cell stations)
- Bounding box in meters
- Display resolution in pixels
- Moving method e.g. shortest distance

Device navigational information

- Device location
- Waypoints
- Terminal point

The current action and the corresponding action parameters, depending on usage

- Object to be searched/located
- Introductory point
- Terminal point
- Pan distance
- Zoom factor

Optional

- Route up to current position
- Travelling/moving method
- Actual speed
- Moving direction
- Terminal point type fixed/moving

The client device must keep track of its own state, and send all state information every time a request is sent to the server. Hence the server runs in a stateless mode, and has no information about the state of requesting devices. This makes the server more efficient, and therefore better performing. On the other hand this puts more load on the client device, and makes it mandatory for the client to have Java capability and enough memory. Enough memory implies memory to run the user device application, store the state information and the map image.

Parts of the information that the server (the Portal Service or the Application Service) sends to the client can be as an XML document complying with GiMoDig.xsd - the schema described in an internal report.

Special focus must be set on the “objectList” element.

4 OpenLS Presentation Service

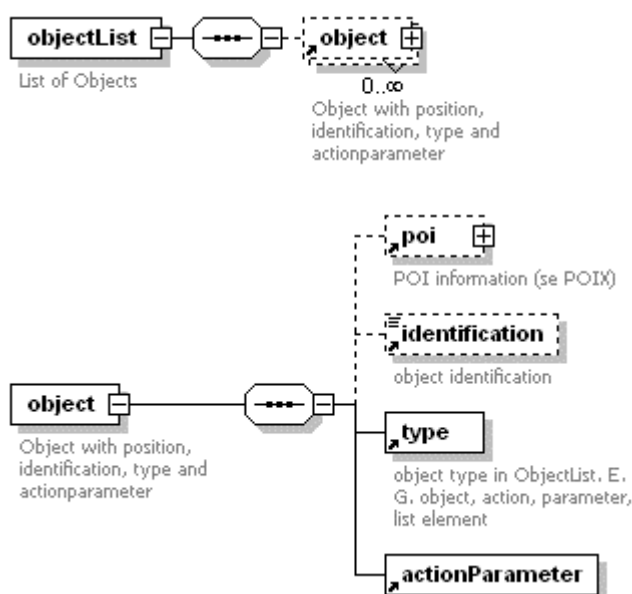
This paragraph describes the protocol developed by WP3 Small-Display Cartography and the OpenLS draft specification from Open GIS Consortium (OGC). Because that specification is still a draft and hence not released, the detailed discussion is included only for restricted use in the Appendix E.

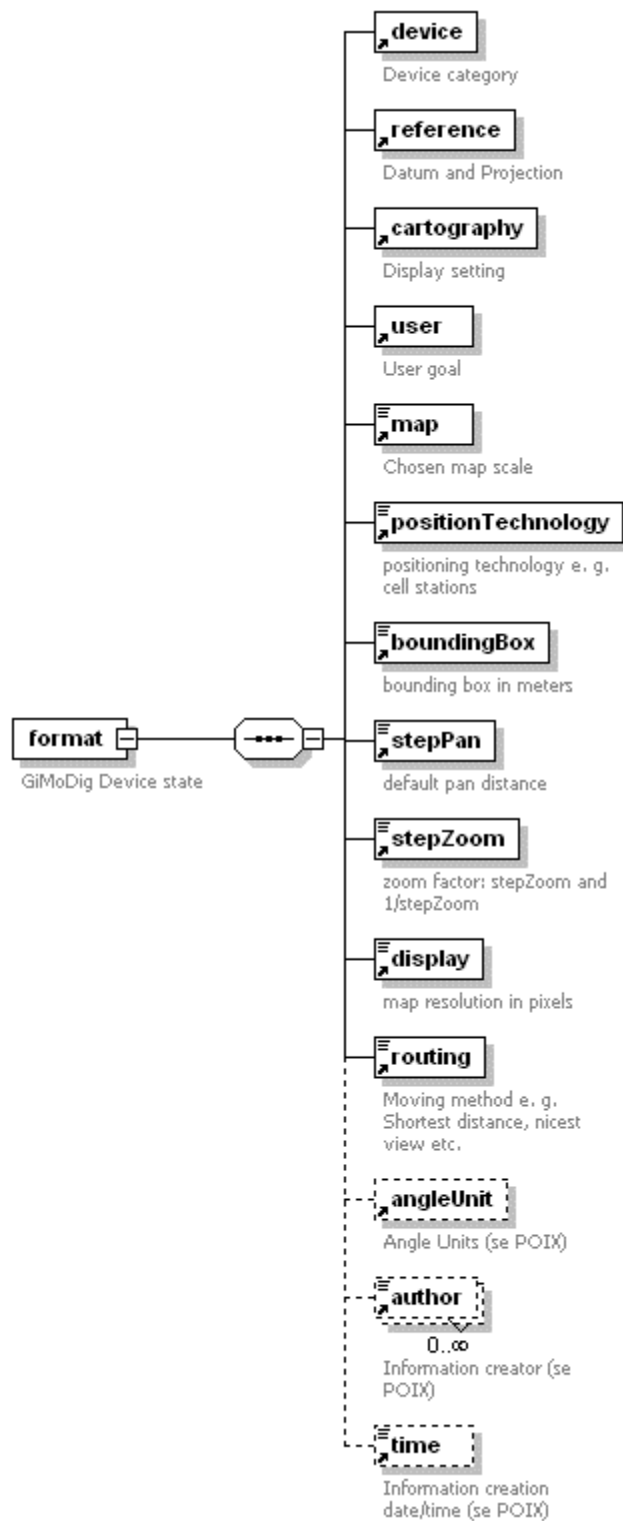
5 Conclusions

5.1 Conclusion on comparison of OpenLS and GiMoDig schema

OpenLS is a flexible schema with most of the elements needed for GiMoDig purposes, the only elements we have to add are:

- ObjectList
- Cartography
- User goal





Part IV

Concluding remarks

1 Summary of results

The WP3 work has brought up a lot of questions and some answers: on one hand the technology, systems and hardware devices, on the other hand the humans and the way they communicate with machines. This situation looks very familiar to the IT-industry, especially in earlier days.

The number of and diversity of handheld devices is growing fast. The standardisation is as always behind the need. Japan, USA and Europe have their separate agendas when developing new services, trying to support own research and development communities.

The designing of navigational cartography has indeed shown (again) how difficult it is to communicate spatial data and systems. The work has concentrated on defining one or two proper use cases narrowing the application span that should output a dedicated cartography. The cartography itself consists of 4 cartographic main elements: text, navigation signs, point-of-interest symbols (POIs) and a map base extract encoded in SVG and viewed accordingly.

When speaking of specifying protocols for client / service - communication, the OGC is soon finishing the work on the OpenLS (Open Location based Services). The comparison work between OpenLS and our own protocol specification showed the possibility and the rationale to adopt OpenLS as basis and then integrate some features from the WP3 work in that field.

The integrated elements from WP3 into OpenLS specification are: mode of cartography, an abstract object list and a user goal facility (e.g. child's position).

2 Discussion on results

Since the results are made from a workload of 6 man-months one cannot expect results with a large or general scope – even if “general framework” is part of the project description.

We argue that the cartography proposed can be used for navigational purposes in the cities and in rural areas for personal navigation purposes depending on the technical preconditions.

The cartography has been tested in terms of graphic readability on a Nokia 7650 phone with a Java-based mini SVG-viewer installed along with some preprocessed SVG-files as input. The test was not as thorough as we could like. The test showed some weaknesses in the a priori design. For example, lacking of contrast between blue green

(marsh/swamp) and blue (watercourse) as well as between yellow green (cropland) and green (forest).

Because of the intended intuitive approach to the colour design we decided not to change to “false” or not intuitive colours at this stage. We could have chosen some pattern to fill the surfaces, but hatching would just have been another way to represent a fill colour and a more creative pattern could be hard to generate and render on-the-fly on a small display device.

3 Topics for further research

The experience obtained in WP3 Small Display Cartography has shown that further investigation and development is necessary. The use cases: “A tourist in an unknown city” and “A bicycle family holiday in the countryside” have shown that other application dependant cartographies will be needed, especially when other potential GiMoDig-like use cases are defined, implemented and used by professionals on specific tasks.

Some issues concerning SVG animation features would be nice to investigate further as they seems to be able to support the navigation task in a more powerful way.

Although the displays on handheld devices are developing towards larger screens and higher resolutions, it is obvious that the challenge for all graphic communicators are to be sure that the data (message) has been send and received and read correctly as information and perceived as useful knowledge.

WP3 has proposed more cartographies to select between: e.g. birds-eye-view which could be a new way to look at the topography from over the top of the buildings in the direction you are headed (perspective view) and a pure sign based “cartography” which is quite similar to earlier in-car navigation systems which showed only direction arrows on the screen without maps or other geographic models.

One could argue that birds-eye-view would infer more building data, e.g. height of building, shape of and texture of the roof and maybe a generalised window outline. This is data that we think will be available in a number of years.

It is clear that additional media like voice and video will contribute to the general human user communication interface. Just as the never ending bulk of interesting data can be geo-coded to nearly every object – physical or logical – humans can survey or create.

An important issue is the total human interface to the device and application. We think an investigation, prototyping and a testing using a thorough method to evaluate the behaviour in well defined situations could be a valuable continuation.

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Appendix A

Categorization of selected handheld devices

Table A1. Wap phones

Manufacturer	Model	OS	ROM/ RAM	Proces- sor	Number of colours	Screen resoluti on	Display size	Remarks
Siemens (June 2002)	M50	?	?	?	Black and white	101 x 64	?	GSM/GPRS WAP 1.2.1 Java
Nokia	6210				Black and white			GSM/GPRS, WAP 1.2.1 Java
	7210 (Q3/02)				4096			Java (J2ME) WAP 1.2.1
	6250					96 x 60	30,6 x 24,1 mm	GSM WAP 1.1
Sony Ericsson	T68				256	101 x 80	34x28 mm	GSM/GPRS WAP 1.2.1 Joystick

Table A2. Smart-phones

Manu- facturer	Model	OS	ROM/ RAM	Processor	Number of colours	Screen resolu- tion	Dis-play size	Remarks
Handspring	Treo Communicat or	Palm OS 3.5.2.H	?/16 MB	33 MHz Motorola	4-bit greyscale	160x160	2.75"	GSM/GPRS
	Treo Communicat or (Q2-Q3/02)	Palm OS 3.5.2.H	?/16 MB	33 MHz Motorola	Farveskærm	?	?	GSM/GPRS
Siemens	SX45	Pocket PC	16/32 MB	150 MHz MIPS R4000	65.536	240x320	57.6x76.8 mm	GSM/GPRS
Nokia	7650	Symbian OS	?/4 MB			176 x 208	35 x 41 mm	GSM/GPRS WAP 1.2.1 Joystick MIDP Java
	9290	Symbian OS EPOC Release 6	?/16 MB (extensibl e)	52 MHz ARM9	4096	200x640	35x110 mm	GSM Personal Java
Sony Ericsson	P800 (Q3/02)	Symbian OS 7.0				208 x 320		GSM/GPRS Java
mm02	XDA	MS Pocket PC 2002	?/32MB	207 MHz Strong ARM	4000	240 x 320		GSM/GPRS Only available in

Manu- facturer	Model	OS	ROM/ RAM	Processor	Number of colours	Screen resolu- tion	Dis-play size	Remarks
								countries that mmO2 operates in. Expected Q2/Q3 - 02
Benefon	Esc!				Grey scale	100 x 160		GPS Maps

Table A3. PDAs

Manufacturer	Model	OS	ROM/RA M	Processor	Number of colours	Screen resoluti on	Display size	Remarks
Handspring	Visor Prism	Palm OS 3.5.2	2/8 MB	33 MHz Motorola	65.536	160x160	3.3"	
Palm	m505	Palm OS 4.0	4/8+64 MB	33 MHz	65.536	160x160	3.8"	
	m500	Palm OS 4.0	4/8+64 MB	33 MHz	Grey-scale	160x160	3.8"	
Compaq	iPaq 3950	MS Pocket PC 2002	32/64 MB	400 MHz PXA 250	65 536	240x320	3.8"	
HP (Q2-Q3/02)	Jornada 928 WDA	MS Pocket PC 2002	32MB/64 MB	TI OMAP- 710 133 MHz	16 bit	240 x 320		

Appendix B

J2ME[tm] devices

This page contains two tables that describe the current world of Java-enabled devices. The tables are as follows:

[Table B1](#) lists Java-enabled devices.

[Table B2](#) lists wireless technologies. It is a companion to Table B1.

Table B1. Java-enabled Wireless Devices

Wireless Technology	Frequency (MHz)	Manufacturer	Model	Java Software	Screen	Available
CDMA	1900	LG Electronics	CX-300L	CLDC 1.0	120x160/8 bits	Yes
CDMA	1900	LG Electronics	Cyber-ez-X1	CLDC 1.0	128x128/2 bits	Yes
CDMA	1900	LG Electronics	I-Book	CLDC 1.0	128x128/2 bits	Yes
CDMA2000 1X	800	Casio	A3012CA	CLDC 1.0, MIDP 1.0	132x176/14 bits	Yes
CDMA2000 1X	800	LG Electronics	C-nain 2000	CLDC 1.0, MIDP 1.0	120x133/8 bits	Yes
CDMA2000 1X	800	LG Electronics	C-nain 2100	CLDC 1.0, MIDP 1.0	8 bits	Yes
CDMA2000 1X	800	Samsung	SCH-X130	CLDC 1.0, MIDP 1.0	128x128/2 bits	Yes
CDMA2000 1X	800	Samsung	SCH-X230	CLDC 1.0, MIDP 1.0	120x160/8 bits	Yes
CDMA2000 1X	800	Samsung	SCH-X250	CLDC 1.0, MIDP 1.0	120x160/8 bits	Yes
CDMA2000 1X	800	Samsung	SCH-X350	CLDC 1.0, MIDP 1.0	128x128/2 bits	Yes
CDMA2000 1X	800	Samsung	SPH-X4209	CLDC 1.0, MIDP 1.0	128x160	Yes
CDMA2000 1X	800	Sanyo	A3011SA	CLDC 1.0, MIDP 1.0	132x176/16 bits	Not yet
CDMA2000 1X	800	Sony Ericsson	A3014S	CLDC 1.0, MIDP 1.0	120x120/16 bits	Yes
CDMA2000 1X	800	Toshiba	A3013T	CLDC 1.0, MIDP 1.0	144x176/16 bits	Not yet
AMPS, CDMA2000 1X	800, 1900	Nokia	3585	CLDC 1.0, MIDP 1.0	95x65/1 bit	Not yet
AMPS, CDMA2000 1X	800, 1900	LG InfoComm	VX1	CLDC 1.0, MIDP 1.0	128x104	Yes
AMPS, CDMA2000 1X	800, 1900	Motorola	T720	CLDC 1.0, MIDP 1.0	120x160/12 bits	Not yet
CDMA	800	Casio	C452CA	CLDC 1.0, MIDP 1.0	120x133/8 bits	Yes
CDMA	800	Hitachi	C3001H	CLDC 1.0, MIDP 1.0	120x162/12 bits	Yes
CDMA	800	Hitachi	C451H	CLDC 1.0, MIDP 1.0	120x143/8 bits	Yes
CDMA	800	Kyocera	C3002K	CLDC 1.0, MIDP 1.0	120x160/16 bits	Yes
CDMA	800	Panasonic	C3003P	CLDC 1.0, MIDP 1.0	132x176/16 bits	Yes
CDMA	800	Toshiba	C5001T	CLDC 1.0, MIDP 1.0	144x176/12 bits	Yes
AMPS, CDMA	800, 1900	Motorola	V60i	CLDC 1.0, MIDP 1.0	96x64	Not yet
GSM/GPRS	1900	Research In Motion	Blackberry 5810	CLDC 1.0, MIDP 1.0	160x160/1 bit	Yes
GSM/GPRS	850, 1900	Nokia	3590	CLDC 1.0, MIDP 1.0	95x65/1 bit	Not yet

AMPS, GSM/GPRS, TDMA	800, 850, 1900	Sony Ericsson	T62u	CLDC 1.0, MIDP 1.0	101x80/2 bits	Not yet
GSM/GPRS	900, 1800	Motorola	Accompli 008/6288	CLDC 1.0, MIDP 1.0	320x240/2 bits	Yes
GSM/GPRS	900, 1800	Nokia	7650	CLDC 1.0, MIDP 1.0	176x208/12 bits	Not yet
GSM/GPRS	900, 1800	Research In Motion	Blackberry 5820	CLDC 1.0, MIDP 1.0	160x160/1 bit	Yes
GSM/GPRS	900, 1800	Siemens	M50	CLDC 1.0, MIDP 1.0	101x64/1 bit	Not yet
GSM/GPRS	900, 1800	Siemens	SL42			
GSM/GPRS	900, 1800	Sony Ericsson	Z700	CLDC 1.0, MIDP 1.0	96x92/8 bits	Not yet
GSM/GPRS	900, 1800, 1900	Motorola	A388	CLDC 1.0, MIDP 1.0	2 bits	Yes
GSM/GPRS	900, 1800, 1900	Motorola	Accompli 009	CLDC 1.0, MIDP 1.0	240x160/8 bits	Yes
GSM/GPRS	900, 1800, 1900	Motorola	T280i	CLDC 1.0, MIDP 1.0		Not yet
GSM/GPRS	900, 1800, 1900	Motorola	V60i	CLDC 1.0, MIDP 1.0	96x64	Not yet
GSM/GPRS	900, 1800, 1900	Motorola	V66i	CLDC 1.0, MIDP 1.0	96x64	Not yet
GSM/GPRS	900, 1800, 1900	Nokia	6310i	CLDC 1.0, MIDP 1.0	95x65/1 bit	Yes
GSM/GPRS	900, 1800, 1900	Nokia	7210	CLDC 1.0, MIDP 1.0	128x128/12 bits	Not yet
GSM/GPRS	900, 1800, 1900	Samsung	SGH-S100		128x160/16 bits	
GSM/GPRS	900, 1800, 1900	Sendo	Z100	CLDC 1.0, MIDP 1.0	176x220/16 bits	
GSM/GPRS	900, 1800, 1900	Sony Ericsson	P800	CLDC 1.0, MIDP 1.0, PersonalJava 1.1.1	320x208/12 bits	Not yet
GSM/GPRS, W- CDMA	900, 1800, 1900	Motorola	A820		176x220/12 bits	
GSM/GPRS, TDMA	800, 900, 1900	Siemens	M46			
GSM/GPRS	800, 900, 1900	Motorola	T720	CLDC 1.0, MIDP 1.0	120x160/12 bits	Not yet
GSM	1900	Nokia	9290 Communicator	CLDC 1.0, MIDP 1.0, PersonalJava 1.1.1, JavaPhone 1.0	640x200/12 bits	Yes
GSM	900, 1800	Nokia	3410	CLDC 1.0, MIDP 1.0	95x65/1 bit	Not yet
GSM	900, 1800	Nokia	9210 Communicator	CLDC 1.0, MIDP 1.0, PersonalJava 1.1.1, JavaPhone 1.0	640x200/12 bits	Yes
GSM	900, 1800	Nokia	9210i Communicator	CLDC 1.0, MIDP 1.0, PersonalJava 1.1.1, JavaPhone 1.0	640x200/12 bits	Not yet

					JavaPhone 1.0		
GSM	900, 1800	Siemens	SL45i/6688i	CLDC 1.0, MIDP 1.0	101x80/1 bit	Yes	
iDEN	800	Motorola	i50sx	CLDC 1.0, MIDP 1.0	111x100/2 bits	Yes	
iDEN	800	Motorola	i55sr	CLDC 1.0, MIDP 1.0	111x100/2 bits	Yes	
iDEN	800	Motorola	i80s	CLDC 1.0, MIDP 1.0	119x64/1 bit	Yes	
iDEN	800	Motorola	i85s	CLDC 1.0, MIDP 1.0	111x100/2 bits	Yes	
iDEN	800	Motorola	i90c	CLDC 1.0, MIDP 1.0	111x110/2 bits	Yes	
iDEN	800	Motorola	i95cl	CLDC 1.0, MIDP 1.0	120x160/8 bits	Not yet	
PDC	1500	Mitsubishi	J-D05	CLDC 1.0, MIDP 1.0	12 bits	Yes	
PDC	1500	Sharp	J-SH07	CLDC 1.0, MIDP 1.0	120x160/16 bits	Yes	
PDC	1500	Sharp	J-SH08	CLDC 1.0, MIDP 1.0	122x162	Yes	
PDC	1500	Sharp	J-SH51	CLDC 1.0, MIDP 1.0	122x162	Yes	
PDC	1500	Toshiba	J-T06	CLDC 1.0, MIDP 1.0	16 bits	Yes	
PDC	800	Fujitsu	F503i	CLDC 1.0	120x130/8 bits	Yes	
PDC	800	Fujitsu	F503iS	CLDC 1.0	120x130/10 bits	Yes	
PDC	800	Mitsubishi	D503i	CLDC 1.0	132x142/10 bits	Yes	
PDC	800	Mitsubishi	D503iS	CLDC 1.0	132x142/10 bits	Yes	
PDC	800	NEC	N503i	CLDC 1.0	120x130/10 bits	Yes	
PDC	800	NEC	N503iS	CLDC 1.0	120x130/10 bits	Yes	
PDC	800	Panasonic	P503i	CLDC 1.0	120x130/8 bits	Yes	
PDC	800	Panasonic	P503iS	CLDC 1.0	120x130/8 bits	Yes	
PDC	800	Sony Ericsson	SO503i	CLDC 1.0	128x128/16 bits	Yes	
PDC	800	Sony Ericsson	SO503iS	CLDC 1.0	128x128/16 bits	Yes	
PDC	800, 1500	Sony Ericsson	SO504i	CLDC 1.0	128x128/16 bits	Yes	
AMPS, TDMA	800, 1900	Motorola	V60i	CLDC 1.0, MIDP 1.0	96x64	Not yet	
W-CDMA		Mitsubishi	D2101V	CLDC 1.0	132x162/18 bits	Yes	
W-CDMA		NEC	N2002	CLDC 1.0	16 bits	Yes	
W-CDMA		Panasonic	P2101V	CLDC 1.0	176x220/18 bits	Yes	

The columns in Table B.1 are as follows:

Wireless Technology and Frequency refer to the wireless networks with which the device can communicate. See Table 2 for additional details on these networks, including a sampling of carrier and brand names.

Manufacturer and Model are self-explanatory.

Java[tm] Software lists the standard software specifications and packages that the device supports. Devices may support additional, non-standard APIs, but these are not listed here.

Screen describes the device's screen, both its resolution in pixels and its colour depth. Colour depth refers to the number of bits per pixel that are used for colour information. One bit implies straight black and white, while two bits or four bits usually refers to four or sixteen levels of grey, respectively.

Table B.2. Wireless Technologies (<http://wireless.java.sun.com/device/> accessed – June 13, 2002.)

Wireless Technology	Frequency (MHz)	Brand Names	Carriers	Locations
iDEN	800		Nextel, Clearnet, etc.	USA, Canada, Brasil, Israel and Middle East
GSM	900, 1800			Europe, Asia
GSM	1900			North America
GPRS	900, 1800			Europe, Asia
GPRS	1900			North America
CDMA	1900	ez-i	LG Telecom	South Korea
CDMA	800		Shinsegi Telecom, SK Telecom	South Korea
CDMA2000 1X	800		Shinsegi Telecom, SK Telecom	South Korea
CDMA	800	ezPlus	KDDI	Japan
CDMA2000 1X	800	ezPlus	KDDI	Japan
PDC	800	i-mode	NTT DoCoMo	Japan
PDC	1500	J-Sky	J-Phone	Japan
W-CDMA		FOMA	NTT DoCoMo	Tokyo, Japan

Appendix C

Pictures of selected devices



Figure1. Sony Ericsson T68 WAP phone.



Figure 2. Nokia 6210 WAP phone.



Figure 3. Nokia 7650 Smart phone.



Figure 4. Siemens SX45 Smart phone.



Figure 5. mm02 XDA.



Figure 6. Sony Ericsson P800.



Figure 7. Compaq iPaq H3835.



Figure 8. How a future UMTS-device could look like (Echtzeitgeneralisierung räumlicher Daten für mobile GIS, Symposium 2002, Königsutter am Elm).







Figure 9. A photo of the test device.

















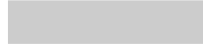




Figure 10. The same as in Figure 9 with the map zoomed out.





Appendix D

Specifications for navigation-oriented small-display cartography

Object/presentation Samples	Graphic definition / sizes	Large scale 1:2.500 - 1:10.000	Medium scale 1:25.000 - 1:250 K	Small scale 1:500.000 - 1:5 M
Text elements				
road/street names "Karl Johan"		Arial 12	-	-
city/town names "Hannover"		Arial 24	Arial 18	Arial 12
village names "Kirke Såby"		Arial 24	Arial 18	-
nature area names "Nuuksio"	> 10 km ² / > 100 km ² / > 1000 km ²	Arial 24/18	Arial 18/12	Arial 12
nature line names "Saxån"	> 1 km / > 10 km / > 100 km	Arial 18/12	Arial 18	Arial 12
Navigation elements		scale less	scale less	scale less
destination 	polygon fill: (#ffff00) stroke: (#ff0000) stroke-width: 1 pix			
direction 	polygon fill: (#ffff00) stroke: (#ff0000) stroke-width: 1 pix			
current position 	radius: 10 pixel fill: (#ffff00) stroke: (#ff0000) stroke-width: 1 pix			
waypoint 	height: 10 pixel, baseline: 12 pixel fill: (#ffff00) stroke: (#ff0000) stroke-width: 1 pix			
POI elements		scale less	scale less	scale less

information kiosk 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			
parking 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			
bus stop 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			
metro stop 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			
city train stop 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			
camping site 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			
hotel / motel 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			
sight/view 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			
restaurant 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			
public toilet 	height: 20 pixel width: 16 pixels fill: (#000077) canvas: (#ffffff) symbol: (#000077)			

Object Type Graphic represent.	Selection criteria	Large scale 1:2.500 - 1:10.000	Medium scale 1:25.000 -1:250 K	Small scale 1:500.000 - 1:5 M
Map elements				
Traf. infrastr.				
ROAD (#FF0000)	HIGHWAY / > 20 M MAIN ROAD / > 10M OTHER ROAD / > 3 M	natur. scale / 3 pix natur. scale / 2 pix natur. scale / 1 pix	width: 2 pixels width: 1 pixel width: 1 pixel	1 pixel - -
FOOTPATH (#FF6600) DASHARRAY (15, 5) 	import. / l. > 100m import. / l. > 1 km -	1 pixel, dashed - -	- 1 pixel, dashed -	- - -
Railway (#999999) 	single / multi track	1 pixel / 1 track	1 pixel / 2 tracks	1 pixel / n tracks
Culture				
Building (#999999)  (min.4 x 2 pix)	> 30 m ² > 100 m ² > 1000 m ²	natur. scale / 8 pix natur. scale / 8 pix natur. scale / 8 pix	8 pixels / - natur. scale / 8 pix natur. scale / 8 pix	- - -
Administrative Boundary (#999999) dasharray (15, 5) 	municip. boundary county boundary national boundary	X X X	X X	X
Build-Up Area (#cccccc) 	> 2.500 m ² > 10.000 m ² > 100 km ²	natur. scale / 20 p natur. scale / 20 p natur. scale / 20 p	- natur. scale / 20 p natur. scale / 20 p	- - natur. scale / 20 p
Cropland (#99cc00) 	> 2.500 m ² > 10.000 m ² -	natur. scale / 20 p natur. scale / 20 p -	- natur. scale / 20 p -	- - -
Nature				
Watercourse (#0000ff)  Shoreline (#0000ff)	> 500 m > 5.000 m > 50.000 m	natur. scale / 20 p natur. scale / 20 p natur. scale / 20 p X	- natur. scale / 20 p natur. scale / 20 p X	- - natur. scale / 20 p X
Forest (#00ff00) 	> 2.500 m ² > 10.000 m ² > 100 km ²	natur. scale / 20 p natur. scale / 20 p natur. scale / 20 p	- natur. scale / 20 p natur. scale / 20 p	- - natur. scale / 20 p
Marsh/Swamp (#99ccff) 	> 2.500 m ² > 10.000 m ² > 100 km ²	natur. scale / 20 p natur. scale / 20 p natur. scale / 20 p	- natur. scale / 20 p natur. scale / 20 p	- - natur. scale / 20 p
Grassland (#ccffcc)	> 2.500 m ²	natur. scale / 20 p	-	-

	> 10.000 m ² > 100 km ²	natur. scale / 20 p natur. scale / 20 p	natur. scale / 20 p natur. scale / 20 p	- natur. scale / 20 p
Lake/Pond/Waters (#00ffff) 	> 2.500 m ² > 10.000 m ² > 100 km ²	natur. scale / 20 p natur. scale / 20 p natur. scale / 20 p	- natur. scale / 20 p natur. scale / 20 p	- - natur. scale / 20 p
Miscellaneous				
Contour Line (#ff6600) 	modulo 5 m = 0 modulo 25 m = 0 modulo 100 m = 0	X	X	X
Airfield (#ffcc00) 	local airfields national airports internat. airports	natur. scale / 20 p	natur. scale / 20 p natur. scale / 20 p	natur. scale / 20 p

The table is a combination of 3 aspects: object definition, map object type selection minimum size criterion and a cartographic specification for each map object type as a function of the resolution (scale).

The abbreviations are rather cryptic: **natur. scale** means the outline or centreline-width of the object portrayed in the specified scale without typefication and symbolisation.

Appendix F

Examples

Example 1. Initial call

This example illustrates the first call from the client to the server asking for the list of available services.

```
<?xml version="1.0" encoding="UTF-8"?>
<GiMoDig xmlns="K:\GiMoDig\Schema\GiMoDig" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="K:\GiMoDig\Schema\GiMoDig
K:\GiMoDig\Schema\GiMoDig\GiMoDig.xsd" version="1.0">
  <GiM>
    <action type="getList"/>
    <objectList>
      <object>
        <identification>initial</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
    </objectList>
  </GiM>
</GiMoDig>
```

In the <GiM> tag the <action type="getList"/> tag indicates a get list request. There must be an object that indicates which list - in this case initial.

Example 2. The response to the initial call

This example illustrates the response from the portal service to the call in example 1.

```
<?xml version="1.0" encoding="UTF-8"?>
<GiMoDig xmlns="K:\GiMoDig\Schema\GiMoDig" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="K:\GiMoDig\Schema\GiMoDig
K:\GiMoDig\Schema\GiMoDig\GiMoDig.xsd" version="1.0">
  <GiM>
    <action type="getList"/>
    <objectList>
      <object>
        <identification>Adresses</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
      <object>
        <identification>Points of interest</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
    </objectList>
  </GiM>
</GiMoDig>
```

```

    <object>
      <identification>Tracking</identification>
      <type objectType="listElement"/>
      <actionParameter>none</actionParameter>
    </object>
    <object>
      <identification>Other</identification>
      <type objectType="listElement"/>
      <actionParameter>none</actionParameter>
    </object>
    <object>
      <identification>End GiMoDig session</identification>
      <type objectType="listElement"/>
      <actionParameter>none</actionParameter>
    </object>
  </objectList>
</GiM>
</GiMoDig>

```

Example 3. Response to request about Point of Interest list

```

<?xml version="1.0" encoding="UTF-8"?>
<GiMoDig xmlns="K:\GiMoDig\Schema\GiMoDig" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="K:\GiMoDig\Schema\GiMoDig
K:\GiMoDig\Schema\GiMoDig\GiMoDig.xsd" version="1.0">
  <GiM>
    <action type="getList"/>
    <objectList>
      <object>
        <identification>Hospitals</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
      <object>
        <identification>Churches</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
      <object>
        <identification>Railway Stations</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
      <object>
        <identification>Airports</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
      <object>
        <identification>Museums</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
      <object>
        <identification>Have Fun</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
      <object>
        <identification>Other</identification>
        <type objectType="listElement"/>
        <actionParameter>none</actionParameter>
      </object>
    </objectList>
  </GiM>
</GiMoDig>

```

```

    </object>
  </objectList>
</GiM>
</GiMoDig>

```

Example 4. Request map with nearest railway stations

This example illustrates the request from the client to the server in order to find the nearest railway station /-s and show a map with the stations indicated.

```

<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XML Spy v4.3 U (http://www.xmlspy.com) by Jorgen Münster-Swendsen (National Survey and Cadastre)
-->
<GiMoDig xmlns="K:\GiMoDig\Schema\GiMoDig" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="K:\GiMoDig\Schema\GiMoDig
K:\GiMoDig\Schema\GiMoDig\GiMoDig.xsd" version="1.0">
  <format>
    <device mode="intelligent"/>
    <reference>utm33_euref89</reference>
    <cartography mode="movingMap"/>
    <user goal="nearest"/>
    <map>10K</map>
    <positionTechnology>cellStations</positionTechnology>
    <boundingBox>1000X1000</boundingBox>
    <stepPan>250</stepPan>
    <stepZoom>1.33</stepZoom>
    <display>200X200</display>
    <routing>shortestDistance</routing>
  </format>
  <GiM>
    <!-- current position -->
    <pos>
      <N>6178904</N>
      <E>722117</E>
    </pos>
    <action type="displayMap"/>
    <objectList>
      <object>
        <identification>Railwaystations</identification>
        <type objectType="listElement"/>
        <actionParameter/>
      </object>
    </objectList>
  </GiM>
</GiMoDig>

```

In the <format> tag the <user goal="nearest"/> tag indicates to find the nearest objects described in the <objectList> section – (<identification>Railwaystations</identification>) and show a map (<action type="displayMap"/>) with these objects on it. The specification for the map is described in the <format> tag.

Example 5. Request map with route to named station

This example illustrates the call from the client to the server asking for guidance to one of the nearest stations received as answer to example 3.

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XML Spy v4.3 U (http://www.xmlspy.com) by Jorgen Münster-Swendsen (National Survey and Cadastre)
-->
<GiMoDig xmlns="K:\GiMoDig\Schema\GiMoDig" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="K:\GiMoDig\Schema\GiMoDig
K:\GiMoDig\Schema\GiMoDig\GiMoDig.xsd" version="1.0">
  <format>
    <device mode="intelligent"/>
    <reference>utm33_euref89</reference>
    <cartography mode="movingMap"/>
    <user goal="nearest"/>
    <map>10K</map>
    <positionTechnology>cellStations</positionTechnology>
    <boundingBox>1000X1000</boundingBox>
    <stepPan>250</stepPan>
    <stepZoom>1.33</stepZoom>
    <display>200X200</display>
    <routing>shortestDistance</routing>
  </format>
  <GiM>
    <!-- current position -->
    <pos>
      <N>6178904</N>
      <E>722117</E>
    </pos>
    <action type="displayMap"/>
    <objectList>
      <object>
        <poi>
          <point>
            <pos>
              <N>6178450</N>
              <E>722306</E>
            </pos>
          </point>
          <identification>Nørrebro Station</identification>
          <type objectType="target"/>
          <actionParameter/>
        </object>
        <object>
          <poi>
            <point>
              <pos>
                <N>6178904</N>
                <E>722117</E>
              </pos>
            </point>
            <identification>car parked here</identification>
            <type objectType="waypoint" number="1"/>
            <actionParameter/>
          </object>
        </objectList>
        <move>
          <method>onfoot</method>
        </move>
      </GiM>
    </GiMoDig>
```

The `<objectList>` contains the object with `<identification>Nørrebro Station</identification>` as the target and the object `<identification>car parked here</identification>` as the starting point.

In the `<format>` section `<routing>shortestDistance</routing>` indicates the routing method.

Example 6. Answer to the request in example 4 (part of-)

This example illustrates the non-graphic response from the portal service to the call in example 4.

```
<?xml version="1.0" encoding="UTF-8"?>
<GiMoDig xmlns="K:\GiMoDig\Schema\GiMoDig" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="K:\GiMoDig\Schema\GiMoDig
K:\GiMoDig\Schema\GiMoDig\GiMoDig.xsd" version="1">
  <GiM>
    <action type="displayMap"/>
    <objectList>
      <object>
        <poi>
          <point>
            <pos>
              <N>6178450</N>
              <E>722306</E>
            </pos>
          </point>
        </poi>
        <identification>Nørrebro Station</identification>
        <type objectType="target"/>
        <actionParameter/>
      </object>
      <object>
        <poi>
          <point>
            <pos>
              <N>6178904</N>
              <E>722117</E>
            </pos>
          </point>
        </poi>
        <identification>car parked here</identification>
        <type objectType="waypoint" number="1"/>
        <actionParameter/>
      </object>
    </objectList>
    <travel>
      <terminalPointData>ETA 15:31:00+01:00</terminalPointData>
      <wayPointData>ETA 15:23:00+01:00</wayPointData>
    </travel>
    <access>
      <method>onfoot</method>
      <ipoint>
        <iclass>others</iclass>
        <pos>
          <N>6178904</N>
          <E>722117</E>
        </pos>
      </ipoint>
      <tpoint>
        <tclass>station</tclass>
        <pos>
          <N>6178617</N>
```

```

        <E>722370</E>
    </pos>
</tpoint>
<route>
  <polyline>
    <!-- Starting point - waypoint 1-->
    <pos>
      <N>6178904</N>
      <E>722117</E>
    </pos>
    <!-- point on route-->
    <pos>
      <N>6178837</N>
      <E>722189</E>
    </pos>
    <!-- point on route-->
    <pos>
      <N>6178801</N>
      <E>722272</E>
    </pos>
    <!-- point on route-->
    <pos>
      <N>6178611</N>
      <E>722256</E>
    </pos>
    <!-- point on route-->
    <pos>
      <N>6178505</N>
      <E>722250</E>
    </pos>
    <!-- point on route-->
    <pos>
      <N>6178473</N>
      <E>722251</E>
    </pos>
    <!-- point on route-->
    <pos>
      <N>6178466</N>
      <E>722261</E>
    </pos>
    <!-- point on route-->
    <pos>
      <N>6178461</N>
      <E>722306</E>
    </pos>
    <!-- Nørrebro Station - target-->
    <pos>
      <N>6178450</N>
      <E>722306</E>
    </pos>
  </polyline>
</route>
</access>
</GiM>
</GiMoDig>

```